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WHAT A SCIENCE CLUB CAN DO FOR A SCHOOL.

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A good deal has been said recently with reference to what a Science Club could do for a high school student. Maurice Meister and others, in recent articles, have shown the advantages to boys and girls of high school age of membership in a science club. That these values are numerous and worth while no one would deny.

But there is another side to the science club situation which should be spoken of and that is the relation of a science club to the school. The school, as well as the student body, gains something. There comes to be a better understanding between students and faculty, a better carrying on of the work in a given department and the club may help in demonstration work in the school.

As I think back to my years as a teacher in DeWitt Clinton High School and look at the modest beginning that the Biological Field Club made over twenty odd years ago, and when I note the progress that this club made over a number of years and remember also the developments in school life that came from it as a pioneer club, I clearly perceive that a science club can have a very large part in the organization not only of science work but in *esprit de corps*, in demonstration work and in real service to the school community.

During the early days of the Biological Field Club, a program was carried out consisting largely of field trips in good weather; occasional trips to nearby museums in the late fall and during the winter months talks by officers and members of the club by means

of which projects (for we had projects twenty years ago) were demonstrated. Sundry informal spreads and social meetings were held and as I look back at those informal meetings, I realize that they did for me as a young teacher what such meetings have done for many others, namely: they gave me contacts with students that I could get in no other way. They made me one of the student body and they gave the students a sidelight on a man who was a friend and a good fellow with them when occasion demanded it. I am sure, indirectly, it did much toward building up the science work in the school. Out of this club work came, I think, the beginnings of a wider scope of departmental activities outside the school laboratory. Field trips were planned in the fall on a huge scale, hundreds of students participated in these trips and the teachers were helped in no small degree by members of the club who acted as laboratory assistants pro tem in the field. As I look back upon the work I can also see that the school's later affiliation with the great American Museum came indirectly as a by-product of the Biology Club's trips to the Museum where possibilities for doing laboratory work in a new environment showed itself in such a clear light.

A little later I look back at the school and I see a still further development of the club idea. We moved into a noble building with a huge lunch room into which poured at lunch time a stream of more or less badly trained boys. They were just boys at lunch time with no ideas of cleanliness or hygienic values. They came largely from foreign homes. The lunch room soon became a bespattered and besmeared place which the more fastidious boy avoided and in which the average boy grew careless. Out of the club group arose a thought of making for leadership in this besmirched democracy and when the idea was broached to a group of picked boys, this group gave itself whole heartedly to the purpose of remedying conditions which were far from pleasant. It was no small job that the "Sanitary Squad," as they called themselves, took over. At first their lot was a hard one. They were scoffed at and made fun of by the older boys, but they pluckily kept up the work. Faculty backing was given them and before long there evolved from chaos a very decided order in the lunch room. It became distinctly bad form to throw paper on the floor or to besmear a neighbor's clothes with pie. It became bad form because the Sanitary Squad, acting as sanitary police, made regulations and enforced

them. It was no unusual thing to see one small boy picking up papers under the stern eye of a member of the Sanitary Squad; or another disgusted youngster cleaning up the pie he let fly at his neighbor, also closely supervised by a boy with a Squad badge.

The squad idea grew, and before long we found in the DeWitt Clinton High School a number of such organizations, headed by the well-known Doty Squad, a group of splendid young men working under a leader of unusual ability. This squad practically took from the teachers the task of disciplining the study halls and corridors of the school. Other squads took over the disciplining of the laboratories, of the school gym and halls and of the study halls. The DeWitt Clinton High School was pointed to as a school in which student government of a certain type showed at its very best.

From a distance, one may analyze a situation much better than when one is at hand. As I look back now upon the school and the work accomplished by these groups, I clearly see an evolution from the early days, when a devoted group of boys working with one or two who were interested in their point of view formed a nucleus which in later years gave rise to these groups which are now doing such excellent service for the morale of the student body in the DeWitt Clinton High School.

I can also see other by-products which resulted to the school as well as to the members of the squad. Not only do the squads and the clubs make for better understanding between students and faculty, for better cooperation as well, but it also made for better demonstration science work in the school.

I have quoted how club members became laboratory assistants in the field; I might also speak of the biology, chemistry and physics stock room squads. Groups of boys who were interested in the chemical, physical, or mechanical side, those who were fond of manipulation of apparatus and who were willing to give their spare periods to this type of work in their respective departments, aided in setting up and putting away apparatus, in collecting supplies and in a hundred and one ways making themselves generally useful in the demonstration of work in the school.

Of the boys who formed the science clubs, some are now making good in professional lines which have directly headed up in the work spent in the laboratory of the high school. Indirectly then the club has been responsible for starting students in a

vocation and in this way directly the student has in turn given valuable time and help to the school. Benefits have also come directly from students who have enjoyed working out projects which could be used for demonstration work in the class room later.

Another interesting by-product to the school is the fact that occasional assemblies may be staged by one or more of these clubs. Outside speakers may be obtained or projects worked out by members of the club may be demonstrated at such assemblies. In this way, indirectly the science department of the school can be built up. This is a legitimate kind of advertising, but an advertising that pays. Student assemblies are always valuable and where a student can make clear the value of a given department in a school these values show more clearly to the students than if they were demonstrated by some member of the faculty or some outside speaker.

In conclusion, then, the club idea is one that is of the utmost value to a school as well as to the students. Not only does it make for better cooperation, for better demonstration work and for the building up of the science department but it also sometimes results in a marked interest of a student in a vocation which may some day bring him back to his own school and make him a valued teacher in that institution.

THE HUMAN SIDE OF SCIENCE.[1]

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Has Science a human side?

To some it seems to act under rigid, rigorous, relentless law and to be entirely concise, cold, cheerless.

To others Science seems to be followed chiefly by those who have some theory they wish to prove and which to them is all important. They are reminded of the man who had a theory that a grasshopper hears through its legs and who set about to prove it: First, he placed the grasshopper upon a board and scratched upon the board and the grasshopper, hearing with his legs promptly jumped. Then he pulled off the grasshopper's legs and again placed him upon the board. This time when he scratched upon the board, the grasshopper having no legs with which to hear the scratching did *not* jump and hence his theory was proven!

[1]Address given before the Arkansas Educational Convention at Little Rock.

It is true that we live in a world of law and not one of these laws under which we live is ever broken. We often say we break such a law, but do we? The law of gravity requires all bodies unsupported to fall to the ground. If you were to step out of yonder window or off of the roof of this building something would be pretty certainly be broken, but it would not be the law of gravity. And yet in this certainty of law lies our sure foundation upon which we build our daily lives. Rain comes down to the earth always—not up from it. I saw a picture in "Life" once based upon the supposition that rain did at times come up; people were going about with an inverted umbrella upon each foot.

In a knowledge of these laws of nature, which really make up nature, and in obedience to them man finds his real freedom.

To illustrate: I hold out this knife which, according to the law of gravity, should fall to the floor but it does not fall. Why? Because so far I have brought to bear upon it another law, that of muscular force, and the puny force of my arm is great enough to overcome so far as this knife is concerned that mighty power which holds the worlds in their proper places. Again, we hear that water does not run uphill and yet, because of the force applied to it in a counter direction, water does run from the river right into this building. Also, ordinarily shout as loudly as I may my voice is heard only a few hundred yards and yet at a broadcasting station where recently discovered laws of wave lengths and of electricity are at work the speaker's voice can be heard across a continent and there is little doubt that soon it will be like the shot "the embattled farmers fired," "heard round the world" ONLY in very much less time.

It is not in any sense my purpose now to recount the wonderful triumphs of modern science, nor to relate how, in almost every phase of our lives, we depend upon its achievements. I believe this statement can not be challenged: There is nothing material of importance in the entire universe for which we are not indebted to science, either for its creation outright or for real knowledge concerning it.

Only by science but by no means by science alone has the advancement of civilization been written. True science seeks to cooperate to the fullest possible extent with every force working for the betterment of man.

Rather tonight would I plead with you as those responsible, that children should come early to see and know the world in

which they live and in this knowledge, growing as they grow' find the fullest life and the greatest happiness.

"But young children will not understand," some one may say. Nor do their elders. You will remember that William Jennings Bryan says that he never could understand why a red cow could eat green grass and give white milk. Tennyson, too, expresses the same thought in his "Flower in the Crannied Wall":

> "Flower in the crannied wall,
> I pluck you out of the crannies,
> I hold you here, root and all, in my hand,
> Little flower—but if I could understand
> What you are, root and all, and all in all,
> I should know what God and man is."

The idea I wish to present and the plea I am trying to make involves nothing highbrow, nothing technical. The wonderful story of the common things of our everyday life is crying to be told. For example, the tree by the schoolhouse, day by day, speaks a most wonderful language and we should help the child to hear and to understand it. In the spring comes the new life, warmed by the sun. Then the forming of its myriad of leaves, which, in the hotter days of the summer store up as man has never yet learned to do, the power in the rays of the sun. And all of this is done so quietly that the fact that "Silent forces are the most powerful" comes home to the mind almost before we know it. And most children need to learn this lesson. Then in autumn there is the beauty of its leaves painted by frost and all the wealth and wonder of color and its importance which they suggest. And lastly, as the leaves fall and we see the bare tree we can see, too, how well it is being prepared to meet the ice and the sleet and the snow of the coming winter. Without this adaptation to its circumstances almost surely would it be broken.

So the snowflakes with their myriad of beautiful forms and yet not one ever fell the axes of whose angles did not conform with the utmost strictness to certain laws. Or, we may think of water and the use of its three forms; of the wise provision of Providence, as I believe, that water as it cools should contract in accordance with the usual law until it is almost cold enough to freeze when a special law of expansion becomes operative, seen all the more in the lightness of ice. Without this special law we should lack many things; not only the tinkle of the ice in our glass of tea, but the tea itself and all of our food, because upon this expansion de-

pends the formation of our soil from the Archaean rocks. And thus we might speak almost without limit.

Not only in nature without the influence of man, but also early let the child know and enjoy the wonders of applied science. Tell him something of steam, of electricity, of sound, of mechanics, not in the abstract, but as seen in the locomotive, the electric light, the telephone, the automobile. Bring him also to compare these machines of man with his own body. The efficiency of the body is far above that of the automobile, for example. The auto breathes out gases only partially burned, giving off the deadly carbon monoxide which makes it dangerous to stay in a closed garage with the engine running. From our lungs carbon dioxide, the evidence of complete combustion, is the product. Our bodies should be good for seventy years without the necessary substitution of spare parts, while even the hardy Ford with spare parts for replacement in abundance cannot approach any such record. Surely then this machine of ours is entitled to as much care as an automobile—a care which it very frequently does not receive.

Valuable as I consider these matters which I have tried to present to you, they are altogether secondary to the guiding principle of science—TRUTH. Early, very early, should the boy and the girl, too, know the unity of truth, that truths never really contradict. By sad experience doubtless we all know how many lies follow one already told in a desperate effort to harmonize. Not so with truth. And so the child should learn as he learns the truths of nature, to love truth for its own sake. He should feel that a lie flies full in the face of Nature and come to hate it. And this search for truth should, as he grows older, make him or her reliable, independent, fearless, a man or woman of conviction.

But not only is there a wonderful value aside from the great material benefit in having our eyes opened to see Nature's laws and the result of obedience to them, to see the wonder of it all and the beauty which is ever present for those who can see; in learning to love truth for its own sake; but it also means much, I had almost said everything, for a child to see whenever he really goes into anything Nature does, always a plan and back of that plan, the God who made it. Tennyson and the flower again! But let us see two from the multitude of ways in which Science is telling this fact.

The hydrogen atom of which we have heard as found in water, H^2O, is very small—so small we are told that 100,000,000 could sit in a row like blackbirds upon a telephone wire upon this little bit of paper one inch long. And yet each of these tiny little fellows rigidly obeys the law. Thus four of hydrogen with one of carbon makes natural gas. By increasing each but always with an exact amount, say fourteen of hydrogen and six of carbon, we have a chief constituent of gasoline. With twenty-two of hydrogen and ten of carbon we have a compound found in kerosene. Likewise by varying the amounts of each we have benzene or toluene or moth balls or turpentine. But the percentage of hydrogen in water or in any other compound containing it never varies whether we take a drop or a million gallons.

When we look at the stars as we leave this building to-night, think that in spite of the fact that light would go around the earth seven times in a single second, that the light which we see started from some of them not only long before we were born, but before there was any United States of America and probably before there was any recorded history. And yet so far as we have been able to observe these bodies move with a wonderful precision so that an eclipse of the sun can be predicted to the fraction of a second centuries before it occurs.

To me this means two things: the mighty power and sweep of God's plan covering all the universe from the most gigantic sun to the tiny, tiny electron of which the hydrogen atom is made; and the placing in man of some spark of His divine life which enables you and me to-night to think in our very weak way His thoughts after Him as we are led by Science.

And so I plead with you that the children of Arkansas may come early in an easy and natural way to know something of Science, of its closeness to us, within and all about us every minute of our lives. I urge this not that the child may talk of kilowatts or chlorophyl or sulfuric acid, but that his life may be fuller and richer as his eyes are opened to the wonders of the world about him, that his heart may be made glad in the love of Nature and her glorious changes, and that his soul may become stronger and more satisfied as he comes to recognize and rest in Him upon whose plan the whole creation moves.

Thus will come a better and a more real understanding of "the Father of Lights with whom is no variableness, neither shadow of turning."

WHAT DAY IS IT?

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Mr. Hugo Brandt, of the Redpath Bureau, is, I believe, the originator of this idea. It is a mathematical process making possible the seemingly impossible feat of giving at once, without reference to tables or like aids, the day of the week on which any given date must fall. We have found this so entertaining at parties and other social gatherings, as well as so useful at times, that we have decided to let out the secret.

"Tell me the day of the month and I will tell you the day of the week corresponding." "All right," your friend says, "my birthday is August tenth. What day of the week will it be?" And you almost instantly answer, "Why, August tenth, 1923, will be Friday of course." He proceeds to ask a dozen more, and you answer all with equal ease, and in less than one-fourth the time that would be necessary to find it on any "perpetual calendar" in the world, even if you had one. The dates given need not be in any special year or even century.

It is an amazing feat and seems wholly impossible. But it really is not so difficult and any one can master at least the rudiments of the system in a half hour's practice. Its mastery will enable you to furnish no end of amusement.

In order to make the relations mathematical and so capable of solution, we first represent the days of the week by numbers—"the day numbers"—somewhat after the fashion of the old Quakers. In this we choose to let:

Sunday	0
Monday	1
Tuesday	2
Wednesday	3
Thursday	4
Friday	5
Saturday	6.

Next we note what we call the characteristics of the months, that is the number of days later than Monday (1) that the month begins. Since we began this system this year and since January this year begins on Monday, we say the characteristic of January is zero. There are thirty-one days in January. That is three days more than four even weeks. This fact causes February to have a characteristic of three. That means simply that it begins the third day after Monday, that is, Thursday. Since

February has twenty-eight days—four even weeks, the characteristic of March will also be three. In this fashion we go through the entire year and find the month characteristics to be as follows:

January	0	May	1	September	5
February	3	June	4	October	0
March	3	July	6	November	3
April	6	Aug.	2	December	5

As an aid in remembering these, beginners may say to themselves: Zero, Three, Three; April 6 (the L is nearly a 6); May (the short name) 1; June (four letters) 4; July (L again) 6; August (two of the letter U) 2; September 5, (I have never found any good memory catch for that); October is like January and November like February; December is like September, similar in name and like in number, 5.

These month characteristics and the day numbers are all that are needed for the solution of questions in this year. The solution is as follows:

What day will fall on August 10? Friday, for:

$$\frac{10 \text{ (the day)} + 2 \text{ (month characteristic)}}{7 \text{ (number of days in a week)}} = 1 \text{ (even week)} + 5/7.$$

But 5 (the fraction of week left over) stands for Friday.

Try another. September 4, 1923, will be what day?

$$\frac{4 \text{ (the day)} + 5 \text{ (month characteristic)}}{7} = 1 + 2/7.$$

Therefore, September 4, 1923, will be Tuesday, the day 2 represents.

One more: Christmas will come on what day? Tuesday, for:

$$\frac{25 + 5}{7} = 4 + 2/7.$$

It can never fail. The rule is: To the day given add the characteristic of the month. Divide the sum by seven and the numerator of the remaining fraction will show the day of the week.

We can solve the problem in this simple fashion only in case both the year and century happen to begin on Monday as the case is now. If the year fails to begin on Monday the answer, as obtained above, will be in error by as many days as New Year

comes after Monday. Fortunately for us, January 1, 1900, was Monday. That means that this century has no characteristic. Since that is true and 1900 was not a leap year, 1901, 1902, 1903 and 1904, until after the leap day in February, will have the year characteristics of 1, 2, 3 and 4. This is true since ordinary years have one day more than even weeks.

So Lincoln's birthday came on what day in 1904?

$$\frac{12 \text{ (day)} + 3 \text{ (for the month)} + 4 \text{ (for the year)}}{7} = 2 + 5/7.$$

Therefore the day was Friday.

1904 was a leap year. Therefore all the months after February, which adds the extra day, will need an extra day added. So the characteristic of 1904 after February will be 5. Therefore July 4, 1904, was Monday, for:

$$\frac{4 + 6 + 5}{7} = 2 + 1/7.$$

So, too, all the years from 1904 to 1908, the next leap year, will need an extra day added. One must use especial care in handling the leap years. The rule for obtaining the year characteristic of all years is: Divide the last two digits by four, add the whole numbers of the quotient to the digits taken and divide the sum by seven. The numerator of the fraction remaining is the year characteristic. An example will make this form of the computation plain.

What is the year characteristic of 1946?

$46/4 = 11$ leap years, that is, days to be added.

$46 + 11 = 57.$

$57/7 = 8 + 1/7.$

Therefore 1 is the year characteristic for the year 1946. The same system may be used for every other year.

This method is a bit difficult for mental computation for we frequently have to handle large numbers. It may be made simpler mathematically by noting that there are certain years that may be called zero leap years. These are leap years having a year characteristic of zero, after February. There are three of these in a century. They are 28, 56 and 84, all products of 28 (4×7). So if it is possible to subtract one of these numbers, the largest one possible, of course, the remainder may be used in finding the year characteristic in place of the original digits. Since these numbers are a bit hard to subtract mentally, recourse is had to the ancient

mathematical trick of subtracting instead the next higher decade number and adding the difference. That is:

For 28 we subtract 30 and add 2
For 56 we subtract 60 and add 4.
For 84 we subtract 90 and add 6.

The great advantage of this system is plainly seen if we take an example, using both methods. Since we obtain the century and year characteristic separately, we work only with the last two digits. What is the characteristic of 1995?

First method	Second method
$95/4 = 23$ leap years.	$95 - 90 + 6 = 11$.
$95 + 23 = 118$.	$11/4 = 2$ leap years.
$118/7 = 16 + 6/7$.	$11+2 = 13$.
Therefore *6*.	$13/7 = 1 + 6/7$.
	Therefore *6*.

The two methods, of course, give like results, but since the numbers dealt with in the second method are so much smaller the computation can be easily made mentally, whereas the first method would be more difficult. With this second method mastered any one who is at all good in mental calculation ought to be able to solve the problem for any day of any year.

To obtain the century characteristic simply add five for each advancing century and two (or subtract five) for each century as we go back. To keep the numbers smaller use only the remainders after dividing by seven. This is somewhat complicated by the fact that some centuries have a leap day and some do not. The leap centuries are 1600, 2000, 2400, 2800, 3200, 3600 et cetera. So as century characteristics we have:

1600. 6 (Five before February 29)
1700. 4
1800. 2
1900. 0
2000. 6 (Five before February 29)
2100. 4 (11 − 7 = 4)
2200. 9
Et cetera.

Greatest care must be used in obtaining dates prior to 1582. At this time the modern calendar was adopted. In that year by Papal decree, the day following October 4 became October 15. This change was not adopted in England until 1752. Then the day following Wednesday September 2 became Thursday Sep-

tember 14, 1752. The modern calendar was not adopted in Russia until very recently.

Let us take now a problem with every possible complication. What day was July 4, 1776?

$$\frac{4\text{ (day)} + 6\text{ (month)} + 4\text{ (leap year)} + 4\text{ (century)}}{7} = 2 + 4/7,$$

Thursday.

Another complex one: February 12, 2001, will be what day?

$$\frac{12\text{ (day)} + 3\text{ (month)} + 1\text{ (year)} + 6\text{ (century)}}{7} = 3 + 1/7,$$

Monday.

We have given the whole of the system for the benefit of those who desire to use it in such difficult cases. In actual practice fully 95% of all questions will relate to the year in which it is used. These will always be capable of almost instant solution, since the year characteristic will be known once for all.

One of the greatest practical uses of this whole idea seems to be in answering the questions: What day of the week is this? or What day of the month is this? If either the day of the week or the day of the month is known, the other follows of course as a mathematical necessity. For example, this morning I was asked: What day of the week is this? I could not instantly say, but I did remember that it was June 30. So I said to myself:

$$\frac{30+4}{7} = 4+6/7.$$

And so I answered at once, "It is Saturday." Suppose I were asked the day of the month and knew it was Wednesday. The problem would then stand:

$$\frac{X\text{ (unknown)} + 4\text{ (month of June)}}{7} = 0, 1, 2, 3 \text{ or } 4+3/7.$$

The whole numbers representing the weeks the 3/7 the fraction for Wednesday. So the day must be either 6, 13, 20 or 27. A person will generally be able to tell which one of the possible ones it is. I generally simplify it and say:

7 (the constant) + the day number − the month characteristic. In this case: $7+3-4 = 6$. This will always give the lowest possible number. The other possibilities are obtained by adding sevens to the first one.

Certain movable festivals, such as Labor Day or Thanksgiving, which bear a definite relation to the calendar, can be easily obtained. Those festival days, such as Easter and certain church days, which depend in part upon the position of the moon, are not easily reckoned. On what day will Thanksgiving come? Since Thanksgiving is always the last Thursday in November, we simply need to know the day corresponding to November 30.

$$\frac{30+3}{7} = 4+5/7.$$

That is, the month ends on Friday, so Thanksgiving will be the 29th.

Similarly, Labor Day is the first Monday in September. Find the day for September first.

$$\frac{1+5}{7} = 0+6/7.$$

That is, September begins this year on Saturday. The first Monday is therefore the third.

By a simple turn this system can be used in helping one to tell a person's age. If a person will give you the day of the week and the day of the month when he was born you can easily determine the years when this combination took place. And since this same combination usually repeats itself only every six years one can usually tell which one applies to the person in question. For example: I was born May 9, 1882. That was on Tuesday. Not all men, but most women, know the day of the week on which they were born. Suppose I had said, "Tuesday, May 9." A simple glance at me would tell that it was not the present century. So the century characteristic would be two and the problem would run:

$$\frac{9\text{ (day)}+1\text{ (month)}+x\text{ (year)}+2\text{ (century)}}{7} = 2, 3 \text{ or } 4+2/7.$$

Our x therefore equals $2+14$, 21 or $28-12$. That is, 4, 11 or 18. But since no year can have a characteristic of over 6, four is the only one possible. So it must have been a year with a characteristic of 4. But only 1899, 1893, 1882, 1876 or 1871, to go back no further, have this characteristic. A simple inspection of your subject will generally enable you to tell which year applies. A little study will make these relations plain. The reward is worth more than the effort.

CHEMISTRY AND PHYSICS TRAINING.*

By IONE GRONNER,

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The fundamental factor of success in teaching is a definite aim. Every teacher, whatever his subject, must have some aim which he expects to realize, must have it before him from day to day, and must so direct the work that it may be accomplished. The formation of correct habits of thinking and living, and the establishment of ideals is the chief end of education. Science, more than any other subject, is fitted for this great work.

The most important habits formed by the study of science, are those of observing, investigating, and understanding the things with which we come in contact every day. Much of the beauty of the world and many of its lessons are lost because the average person fails to observe. The student of science cannot from the nature of his work be indifferent to his surroundings. He sees the working of laws and principles in all his surroundings. His knowledge of machines and electricity enable him to understand and appreciate the appliances so common and necessary to our present mode of living.

Most closely allied to the habits of observation, investigation, and understanding is that of conservatism in forming and adopting conclusions. The study of science with its training in generalizing helps the person to be more careful in drawing conclusions. He knows, from experience, that, of the great mass of data on a question, some facts are of more importance than others; he knows that he must select these important facts and group the others around them before he can draw any

*In suggesting that this article by Miss Gronner be published, I did not presume that it contained particularly new and hitherto unsuggested ideas. The facts are these: Miss Gronner graduated from a good high school in northern Illinois in 1919. She then came to the Illinois State Normal University and began work upon our senior course. After the course of four years she has received the degree of B. of Ed. She has had no experience in teaching outside of our Practice School. Miss Gronner is one of our youngest graduates receiving the degree.

So far as I have knowledge this theme was the unassisted and unsupervised production of a young woman who had a good high school course and a four-year course here at the Illinois State Normal University as a foundation.

It occurs to me that both beginning teachers of science and mature science teachers can hardly help being interested in ideals which a young girl graduate may have gathered in her high school and normal courses regarding proper methods of science instruction in our high school.

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conclusions and he will from habit apply this method to drawing conclusion in other matters.

The formation of painstaking habits is one of the most useful results of the study of science. Care in observing phenomena and in taking data is necessary for the success of any experiment. A slight error in measurement may cause the failure of the experiment. In discussion care is just as important. Many words are spelled much alike and if enunciation is poor the wrong meaning will be conveyed. Such words are "reflection" and "refraction" or "ferrous" and "ferric" In choosing chemicals extreme care must be used for the use of a wrong chemical may cause a serious explosion.

Elimination of self in the performance of a task is very necessary for successful work. In no work is this element so essential as in the study of science. The student must, above all else, be open-minded and ready to receive the results of successful experimentation whatever he had previously believed or expected. The student of science works deductively and not inductively; that is he draws conclusions from what he has done and does not seek to prove some preconceived idea.

There is a wealth of valuable knowledge in science. Not a comfort or luxury, which we enjoy today, was discovered except as the discoverer applied consciously or unconsciously the laws and principles of science. Perhaps we think first, in this connection, of our electrical machinery and appliances, our telephones, telegraph, wireless, and steam and gas engines. These are only a few of the inventions and discoveries and are the cases in which the application of science is most evident but we fail to think of the discovery of fire and the invention of our simplest and earliest implements as the results of science; without the application of the laws of physics and other sciences these would be impossible. It is the duty of every person to know some of these great laws and principles which have made civilization possible.

These are the most important habits and ideas which the teacher should seek to develop and toward which he must direct all his teaching. It is true that these habits will not be well established by the time the pupil leaves high school but the pupil will go on and continue to develop them in after life and that many of them will continue the study.

How are these aims to be accomplished? Woodhull[1] says, "The

[1]Woodhull, The Teaching of Science. Ch. III., p. 24.

history of physics in secondary schools for the past twenty-five years naturally divides itself into two periods. During the first thirteen years of this period physics was taught without help or hindrance from the colleges and it progressed against fearful odds until twenty-four per cent of all the secondary pupils were studying the subject; during the last twelve years the colleges have dominated the physics teaching of the secondary schools through their syllabi, interpreted and enforced by their examinations, and it has declined until the number of pupils has been reduced to ten per cent. Twelve years ago twenty-four per cent of the students selected physics voluntarily, now a considerable part of the ten per cent study it only by compulsion. A similar statement might be made about science in general.[2] Professor Louis Sherman Davis says, "Interest in a science is proportioned to the immediate bearing which its subject matter has upon the life of the student. Hence the matter and process with which chemistry deals should touch the life of the student as closely as possible." This is the answer to the situation. Science in the last few years has not developed these habits but there is no reason why it can not if the teacher seeks to make the work practical and surely there has never been a time in the history of the world when there has been so great an opportunity for this work.

There are several methods now in use, the first and oldest of which is the lecture method. Until rather recently this method was the only one. This method has several good points and several bad ones. The teacher with his greater experience and knowledge can present the work in a more logical and clearer way than the pupils can do. Work thus presented should be less difficult for the pupils to get. The teacher can often give the pupils work by this method which they could not get by themselves, or he can give it so that they can have a better understanding and appreciation. If, however, the teacher is not skillful in using this method it will result in more harm than good. At its best, it is a second-hand method of study and the pupils are likely to rely upon the teacher to do the thinking for them and will absorb as much as they think necessary. When this method is used the pupils should read the material for themselves, if possible, and as much as they can from it, then the additional points and the organization of the teacher will be of much help. No method which deprives the pupil of the

[2]Woodhull, The Teaching of Science, Ch. III, p. 33.

opportunity to think and reason out problems for himself should ever be used to any considerable extent. Unless the pupils are encouraged to question and discuss the work freely they will not develop the conservatism in accepting and making conclusions which is one of the aims of education. This method is particularly bad for the slower pupil. Being naturally slow he must have time to think about each point and to relate the new to the old. This opportunity is denied him and he loses many valuable points. Those few points which he does succeed in getting are disconnected and so confused that the whole lesson is a failure as far as he is concerned. This method affords little or no opportunity for recitation and self-expression which is one of the things which we should stress in all of our work. Although this method may be used occasionally it should never be the basic method in teaching high school pupils, and it should be understood that the pupils are free to interrupt the teacher at any time if the work is not clear or if he differs from any statements made.

Closely related to the lecture method is the development method. This form is the most dangerous and difficult of all methods and requires a skilled teacher in its use. The teacher must be a logical thinker and skilled in asking thought-provoking questions or the lesson will degenerate into a guessing exercise. Teacher and pupils must have a definite aim in mind or a problem to be solved and must direct all questions toward that solution. A teacher put this question to a pupil, "If a train is going north, on which rail does it press the harder?" The question of inertia was brought clearly before the mind of the pupil by asking questions relating to the effect of inertia as exhibited by the starting and stopping of trains and street cars. The next questions brought out the rate of movement of two points on the same meridian but on different parallels. From the data thus obtained with a knowledge of the direction of rotation of the earth, the problem was solved. This is a true development exercise. The training obtained by such an exercise is very valuable and the knowledge thus obtained will be retained much longer than that obtained from a book. Is the value obtained from such an exercise worth the great amount of time necessary for its completion? I think not. The same training can be gained in other ways with less expenditure of time.

One of the methods most widely used today is the text-book method. The use of this method has increased since the im-

provement of printing and the manufacture of paper until now it is used from the primary department through the university. The application of this method to the teaching of science has been more difficult than in the case of any other subject due to the scarcity of text-books adapted to the use of high school pupils. This obstacle is being removed as new high school text-books are being written. In the past, facts have been misrepresented because authors felt that scientific facts and principles could not be understood by pupils of this age. Now we know that these facts and laws can be stated in such a way that the pupils can understand them and appreciate them, at least to a certain degree. Some errors, will however, be found in these books and the teacher must be alert and able to correct them in presenting the materials. The appearance of errors may be of great benefit to the pupils if the teacher is careful for they will help to develop the attitude of criticism on the part of the pupils and will help them to break away from the habit of accepting, as truth, any statement which they may find in print. In selecting a text-book the teacher will usually select that one which presents the work in the most logical, acceptable and clear way. The selection of the text is only the first step in the successful use of this method. The most important thing is that the teacher be able to use the text after it is selected. In many cases a poor text-book in the hands of a good teacher is better than the best text-book in the hands of a poor teacher. The chief aim in the teaching of physics and chemistry is not the teaching of reading, although the ability to read intelligently is very essential, but the formation of scientific habits of thought, study and investigation. These habits will not be developed under the direction of the teacher who says, "Tomorrow we shall take the next five pages" and tomorrow he calls upon the various members of the class to tell what they read on those pages. Such a procedure is bad in teaching any subject, but it is doomed to failure in teaching science. In making an assignment the teacher must have a definite purpose in assigning that particular unit rather than some other one, and must give such questions to guide the study of the pupils as will aid them in accomplishing the purpose. The questions should be of such a nature that the pupil cannot find the answer directly, but by a mastery of the assignment can reason out the answer. Such training is invaluable to the pupil. The pupil should be taught to look upon the text-book as a reference book and a guide, not as an

infallible authority. It should be to him the natural place to seek information to guide him in his reasoning and to be consulted as one of many reference books.

As a result of education, correct study habits should be formed. The only way to develop these habits is to supervise the study of the pupils, and the only way to do this is to have it done at school. In many cases home study is impossible and according to King[3] the average amount of study is from five to eight hours per week. Fifty-nine percent of the high school pupils spend less than five evenings per week at home. The conditions in many homes make study almost impossible. Colvin, in *Introduction to High School Teaching*,[4] says: "The physical conditions of the home make concentration on the assigned lesson extremely difficult, and at times impossible. Home study tends toward irregular habits of work." In a study made by T. M. Giles,[5] it was found that "1. Twenty-five percent of the students have no definite time to study; 2. almost fifty percent of the students have no separate room in which to study; 3. most of the students are using some form of recitation for fixing the material in mind, but it is equally evident that from fifteen to twenty percent apparently have no particular method of study. It is for these students that our study helps are needed." Poor lighting and hearing in the homes hinder effective study but this defect can be removed by having the study done at school. Supervising the study of the pupils gives the teacher an opportunity to see wherein the study habits are wrong, and also an opportunity to suggest better ones. The presence of others who are studying is a great factor in the ease with which a pupil can concentrate upon his work and much time can be saved and many mistakes avoided because the teacher is present to correct and guide the work when necessary. At home the pupils are often unable to get an answer to their questions or they receive a wrong one and further work is impossible and worthless.

There are several objections to supervised study raised by those who do not understand the present conditions and the great possibilities of the new plan. One of the weakest and most frequent objections is that supervised study increases the expense of education. Supervised study need not be more expensive than the old method for it can be carried on by the

[3]King, The High School Age. Ch. XI.
[4]Colvin, Introduction to High School Teaching. Ch. XVII.
[5]The School Review 22, Sept. 1914, p. 478-84.

regular teachers. Expense, however, should not be a determining factor when the results obtained are sufficient to repay the increase, and in this case they are.

Several plans for supervising the study of pupils have been worked out. The double period plan is the best, but in small schools it would mean an increase in the expenses of the school because the teachers could not teach as many classes and hence more teachers would be needed. Under this plan one period is given to study and the other to recitation. The study period may be divided in two ways: first, a large part of the period may be given over to the assignment and in discussing the important points and explaining the parts which are likely to give difficulty or second, the assignment may be shortened and the emphasis placed upon the study during which time the teacher helps those who need help by asking questions or offering suggestions. A cheaper plan and one which may be employed by any school without extra expense is the divided period plan. The period under the usual plan is divided into two or three parts, five minutes for the assignment, ten minutes, once in a while, for review, and the remainder for recitation. The new plan provides for fifty or sixty minute periods. One half of the period is devoted to recitation, and one half to supervised study. The study period is used as in the double period plan.

Supervised study can easily be carried on in a science class although it may not be established in other classes. A science course is given two periods a day, but often only on two days per week are they both used. On recitation days the second period might easily be used in studying the following lesson as is done in the double period plan.

The main objection to supervised study, and this objection is rapidly losing weight in many instances, is that the pupils become independent. It is true that in the past teachers have tried to supervise study when they have not understood the methods but the Normal schools and colleges are beginning to give such training and the teachers are becoming better able to cope with the situation.

The laboratory work is a fundamental part of the study of science, and in none is it so true as in the teaching of chemistry. Chemistry without the laboratory becomes a study of abstract laws, principles and symbols. This is true also in physics, but to a somewhat lesser degree because the pupils are working with objects with which they are more or less familiar. The spirit

of investigation is developed almost entirely in the laboratory. The pupil performs an experiment, and if the work has been properly presented, questions arise which he cannot answer. The best pupils will restudy their experiments and attempt to answer their questions. If they are not answered by this time the natural source of information is the text book or other reference book. The laboratory is the place to train the personal observation. It is very necessary for the pupil to observe very carefully all results and reactions lest he overlook some important phenomenon and thus make his work inaccurate or useless. The good teacher will use the great world about him to explain and illustrate the laboratory work. This introduction, into the laboratory, of outside material will not only help to train the pupils in observation, but will also make the course more practical, interesting, and worth while.

There is one possible danger in laboratory work. Science is finding out new things every day; hence the number of principles and the amount of subject matter is increasing. The danger is that the teacher will attempt to do too much work, and will not go deeply enough into the work to secure the desired results. This difficulty can easily be removed. It is not necessary for the teacher to take up every principle and theory, but a selection of the most important facts should be made, and upon these attention should be centered. After the important ones have been studied and are understood, those of lesser importance may be taken up if there is time.

Success with the laboratory method depends perhaps, more than with any other method, upon the teacher. Pupils, if left to themselves with a manual of directions, will never develop those qualities which they should develop from a study of science properly taught. The teacher must be in the laboratory at all times to guide and direct the pupils. He should be going about asking questions and offering suggestions, when necessary, but not answering questions which the pupil can answer for himself with a reasonable amount of effort. When questions arise the teacher should offer some principle to solve the problem or suggest some reference book where the needed information can be obtained thus making the pupil feel responsible for the solution of his own problems instead of depending upon the teacher. It is not expected, nor is it always best, that the laboratory period be devoted entirely to laboratory work. An important question will often arise, and it is best to stop the

laboratory work for the time to answer the question. The laboratory work should always be discussed in the recitation or lecture work the next day. In this way the teacher can clear up any misconceptions and emphasize the important facts.

A very important part of the laboratory work is the notebook writing. It is in this work that the pupil learns to select and arrange data, and to express himself clearly. The notebook should be written in such a way as to require the pupil to review his experiments and to organize his data. The purpose and method of the experiment must be brought before the student before he begins his work, and they must be kept in mind as he performs his experiment but in writing up the account of his work he must not only understand it himself but must be kept in mind as he performs his experiment but in writing up the account of his work he must not only understand it himself but must be able to express it in such a way that others can understand it. The conclusions which the pupil draws are very important not so much as conclusions but for the training in generalizing which they afford. The notebook should not be a record of laboratory work only but an outline of the course. It should be in such a form that the pupil can look through it and see what points were emphasized in class, and what reference work was done, as well as what exercises were performed in the laboratory. The notebook should be a daily record of the progress of the course and should show the logical connection of laboratory and class work.

Closely connected with the laboratory method is the project method. The solution of a project or problem lends interest to any subject, but physics and chemistry are particularly well fitted for the employment of this method because of their practical application. The selection of the project should be made, by the pupil, on the basis of its interest to him. The choice should be made from a list of practical problems suggested by the teacher. There is one difficulty which presents itself here and that is the difficulty of selecting problems which do not require a knowledge of manipulation beyond the pupil's ability. The second step is the collection of material and information necessary for the solution of the problem. The pupil should be encouraged to find as much material as possible without the aid of the teacher. This may be found in the textbook, reference books, or magazines. The project should form a part of both laboratory and recitation work, and should, as

far as possible, be worked out in its natural setting. The principles learned and applied in working out the project readily suggest themselves in other situations and encourage the pupils to do their own thinking rather than depend upon the teacher.

C. E. Osborne[6] has written an article in which he tells how he increased local interest in chemistry. His work was carried on in the Oak Park and River Forest Township High School. When Mr. Osborne began this work there were seven pupils studying chemistry to one hundred sixty studying other subjects. Now there are almost as many pupils studying chemistry as all the other sciences combined. His plan was this: First, there were lectures to the pupils on *Some Interesting Chemical experiments* such as *soda water, food*, etc., second, a series of practical experiments on *Tests for food constituents, water analysis, milk analysis, Tests for adulterants* and other similar experiments. Third, a board of food inspectors who purchased foods at the local markets, and tested them in the laboratory was appointed. Fourth, lectures were given before clubs on the application of chemistry to life. Fifth, articles on *Our Local Food and Milk Supply* were printed in the paper. Sixth, the class made a visit to a model bakery, a model dairy, and a model ice plant. Eighth, on the laboratory walls were displayed a large number of cards bearing such inscriptions as: The Chemistry student is not so easily duped by fake dopes and fake "docs"; "The Chemist has run the food fakir to earth"; "A knowledge of chemistry is an aid to good health." Ninth, a bulletin board was employed. Upon this were posted pictures of noted living scientists, articles from magazines, and any other thing which pertained to chemistry. Tenth, a serious attempt was made to show the application of each day's lesson to every day life and industry.

The exhibit was held at the close of the year and the pupils worked throughout the year for it. A list of experiments was made out at the beginning of the year, and each pupil was expected to select the experiments which he wished to perform. After selecting the experiments he was expected to gather all the data which he could find. When this was done the teacher looked over his work, and offered suggestions and other information and helped to select the important parts of his data. The material was then organized and the work in the laboratory begun. The pupil did all his work under the supervision of

[6]School Science and Mathematics: 21, Feb. 1921, p. 128-34.

the teacher. The day of the exhibit, the laboratory was made as attracitve as possible by placing, around the walls, posters and cards with inscriptions. The pupils worked their experiments and showed the results to the visitors. On large projects pupils worked in groups as in the case of milk and water analysis. The people of the community visited the exhibit and in this way came in touch with the work of the department and encouraged the pupils.

One of the newest methods of teaching is by means of moving pictures. Although the moving picture is not new, its importance as an educational factor is just coming to be realized. They can be used in many fields of education and science is no exception to the rule. In[7] the teaching of physics and chemistry, the pictures can be substituted for some of the laboratory work. The regular course is crowded with important material. Why not shorten it by demonstration with moving pictures? The pupils in chemistry are not experienced in handling the apparatus and waste much valuable time and materials. By the use of the pictures they can see how each piece of apparatus should be used, and then can begin work more efficiently. The pictures increase the interest of the lectures, and take the place of many demonstration exercises. The aim of chemistry teaching, according to the College Entrance Examination Board, is: "to emphasize, as opportunity offers, the essential importance of chemistry to modern civilization." There is no easier way to bring before the pupils the industrial processes than by moving pictures, and there is often no other way. The class discussions of the pictures should bring out the important points. It is often best to discuss the pictures as they are thrown upon the screen thereby bringing out the important facts and calling attention to the points likely to be missed. The pupil should be left to draw his own conclusions. Many of the experiments may be reworked by the pupils, the previous experience enabling them to work more rapidly and accurately.

The question of the method and content of examinations is a very important one. The examination should not be a test of the pupil's ability to remember the facts of the text, but should be a summary of all the work covered in the time for which the test is given. The questions should call for thought as well as information. Some of the problems should be new ones the solution of which calls for a knowledge of the principles and

[7]Moving Pictures in the Teaching of Chemistry, Visual Edl. 1: 18-23.

facts of the text. Monthly examinations should be given so that the teacher may see what points have not been made clear and may correct the mistakes. Term examinations should serve as a summary of the course and should show the logical sequence of the work from month to month. Long examinations are not always necessary. The teacher can often find out, by short examinations as much as by long ones. Such examinations as leaving a blank to be filled in are good and save much time. As a rule the pupils should not be told that the examination is planned as they will not be so likely to be prepared from day to day. In the case of term examinations however it is different and opportunity for review and organization should be given.

None of these methods described should be used alone. Each has advantages and each has disadvantages. It is only as the teacher selects the best points of each method that the aims of science teaching can be accomplished.

PREPARATION OF TEACHERS OF MATHEMATICS FOR JUNIOR HIGH SCHOOLS.

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The answer to the question as to what constitutes proper and adequate preparation for teachers of mathematics in the junior high school depends upon what years are included in the junior high and upon the nature and scope of the mathematics taught in these years. For the purposes of this paper it is assumed that the junior high school is composed of the seventh, eighth and ninth school years and that the mathematics of these years should include arithmetic, geometry, algebra and some trigonometry, similar to the work recommended by the National Committee on Mathematical Requirements. (Bureau of Education, Bulletin, 1921, No. 32.)

Under these conditions teachers of mathematics in the junior high school need a type of preparation quite different from that needed by teachers of arithmetic in the elementary school or by teachers of mathematics in the senior high school. Little has been done so far by our colleges and teacher training schools in the direction of supplying this specialized training. Many institutions are offering courses dealing with the history, organization, methods of teaching and the curriculum of the junior high school and short courses on the teaching of mathematics in these schools, but few are offering systematic courses of

training planned especially for the preparation of teachers of mathematics in the junior high school.

As a result it is almost impossible at present to find a teacher who has been specially trained for this work. Our junior high school teachers of mathematics today are being drawn largely from two classes (1) from upper grade teachers having somewhat superior mathematical ability and graining and with possibly a little special preparation gained through courses such as those previously mentioned, and (2) from young and usually inexperienced teachers who have completed or partially completed a course of training for teaching in the senior high school.

In general, neither of these classes furnishes teachers competent to teach mathematics in the junior high school. Those belonging to the first class are apt to possess superior teaching ability but are usually deficient in mathematical knowledge and training. Those of the second class may possess adequate knowledge of formal mathematics but usually have no special fitness or preparation for the teaching of junior high school mathematics and their training is usually such that they are out of sympathy with the simplified concrete mathematics of these years.

I recently attended a meeting of high school teachers of mathematics at which the question of junior high school mathematics was under discussion. Almost without exception, the group argued that geometry and algebra should not be taught below the ninth school year and that they could get "better results" from the use of the older formal algebra and geometry texts than from any of the "new-fangled" texts written for the junior high school. Some of this group were mature teachers who had taught for years in the old four year high school, but many were young men and women recently graduated from college and with excellent mathematical equipment, but, because of their training, totally out of sympathy with the modern conception and trend of junior high school mathematics.

I am thoroughly convinced, therefore, that if the mathematics taught in the junior high schools is ever to be anything different from traditional arithmetic and formal algebra, the teachers in these schools must be given a specialized course of training. It is the purpose of this paper to consider what the extent and nature of this preparation should be.

Ideally, junior high school teachers should have training equal

in extent to that demanded of senior high school teachers, namely, a four year college course. Indeed, if anything, teaching in the junior high school demands superior training and ability. This is especially true in mathematics if we agree that one of the chief purposes of the mathematics of these years is to help the student to find himself, to determine whether or not he has any special liking for and ability in mathematics, so that he can intelligently decide whether or not he cares to pursue his study of the subject beyond the work required of all students. The time is coming when all mathematics beyond the junior high school will be elective. The world, however, will continue to need trained mathematicians, and so it will become of the utmost importance socially that the teacher of mathematics in the junior high school shall be able to present the subject in such a concrete, practical and interesting manner that all students fitted to continue the study of the subject will want to do so. I am told that a well-known mathematician recently said that he could see no objection to making mathematics elective beyond the junior high school, but added that if he were principal of a junior high school, and all of the pupils did not elect to continue the study of mathematics, he would fire all of his mathematics teachers as incompetent. This is perhaps an exaggerated statement and there are probably some students who cannot be interested in mathematics and who should not be encouraged to pursue its study beyong the elements, but the fact remains, as you and I know, that mathematics can be made intensely interesting to many, perhaps even to the majority of the students, and this is the peculiar function of the teacher in the junior high school. To do this certainly requires knowledge and preparation of a high order.

At present, however, in many places junior high school teachers receive neither sufficient professional nor financial recognition to make such positions attractive to those having four years of college work. Until junior high school teaching is put on a level with senior high school teaching in public estimation, it would seem advisable that institutions offering courses for the preparation of junior high school teachers should provide both three-year and four-year courses of training. The three-year courses should, however, be regarded as being temporary and should be discontinued as soon as conditions permit.

Adequate preparation for the teaching of mathematics in the junior high school, as I see it, must provide six things. (1)

A knowledge of psychology and of educational theory with particular emphasis on the psychology of adolescence and upon the problems of the junior high school. (2) A thorough mastery of the portions of mathematics to be taught and a comprehensive knowledge of their important applications. (3) Familiarity with the best methods of teaching these parts of mathematics. (4) Some skill and technique in teaching gained through observation of skillful teaching and through practice teaching under competent supervision. (5) A knowledge of mathematics extending as far as possible beyond the elementary phases to be taught. (6) A knowledge of the history of the subject.

In psychology and education the course of instruction should include courses in elementary psychology, educational sociology, history of education, principles of teaching with special reference to the junior high, educational psychology with emphasis on the psychology of adolescence, and high school organization and administration with special emphasis on the junior high school.

The student should also be given a short course dealing with the aims, organization and administration of junior high school mathematics including (1) a study of the aims and purposes of mathematical instruction in general and in the junior high school in particular; (2) a consideration of the content necessary to the accomplishment of these aims in the junior high; (3) a study of possible plans of organization for this content. This course should also consider such topics as the use of standard tests in arithmetic, algebra and geometry; the mathematical library for the junior high school; interesting mathematical puzzles, tricks, curiosities and recreations; and mathematical clubs.

To assure an adequate knowledge of the portions of mathematics to be taught, the course of training should include teachers' courses in arithmetic, geometry and algebra. These courses should thoroughly review these subjects and should also consider the best methods of teaching them in the junior high school. To my mind these courses should constitute the one most important phase of the prospective teacher's preparation. Successful teaching demands first and foremost a thorough knowledge of the subject matter taught, and second a knowledge of methods that can be successfully employed in presenting this subject matter to the pupils. These two things, mastery of subject matter and of methods of teaching, can best be obtained in a

combined course. To divorce the two results in both a waste of time and a loss in concreteness.

Some people might question the necessity for such courses on the grounds that the work already done by the prospective teacher in arithmetic, geometry and algebra in the elementary and high schools should be sufficient. A few years ago I would have been inclined to agree with this point of view, but the more experience I have with high school graduates perparing to teach mathematics, the more thoroughly convinced I become that a review of even the most elementary protions of the subjects they are preparing to teach is one of the most important and essential parts of their preparation. No matter how well the prospective teacher may know arithmetic from the utilitarian standpoint, he does not know it from the point of view of the teacher of the subject. It is a common remark that one really never knows a subject until after he has tried to teach it. In the past the teacher has often mastered the subject as he was teaching it and for the first year or so of his teaching experience has often been only a jump ahead of his class and sometimes not even that. To give no course in arithmetic in college and to expect a student to teach it often not having studied the subject for from four to eight years, is unreasonable.

A teacher's course in geometry is just as essential as one in arithmetic. Not only has the prospective teacher not studied the subject for a number of years, but the type of geometry that he has studied is probably quite different from that he would have to teach in the junior high school. It is not at all uncommon to find college students who have "gone through" the usual high school course in formal geometry but who have had no experience in practical geometric measurements. Many of them have had little experience in making measurements of any kind, have never used a protractor, cannot draw the altitude of a triangle and find its area, and have had no experience in field work. They have some knowledge of formal demonstrative geometry but know nothing of simple experimental methods of discovering and verifying geometric truths, and have little, if any knowledge of the practical applications of the subject. To say that such students can be prepared to teach junior high school geometry by any amount of study of advanced college mathematics or of methods alone is obviously ridiculous to anyone who is familiar with the character and spirit of the mathematics being projected for the junior high school of today.

The Teachers' Course in Algebra might seem less essential than the other two as the student's study of college algebra and of the other courses in college mathematics will serve to give him a rather thorough review of the elements of alegbra. The point of view and spirit of these courses, however, is necessarily quite different from that of the junior high school. It is therefore essential, it seems to me, that the student be given a course dealing with the fundamentals of algebra and with methods of simplifying the work and making it concrete and meaningful.

Some people also object to such courses on the grounds that they are too elementary and too easy to be deserving of college credit. If they are properly organized and properly taught they can be made as worthy of college rank and credit as courses in advanced mathematics or in education.

The chief purposes of the arithmetic of the junior high school are first to provide further drill on the fundamentals, second to familiarize the pupil with some of the most important applications of the subject, and third, to develop some ability to use arithmetic in typical life situations. The junior high school teacher must, therefore, thoroughly understand the psychology of drill and of problem solving, must be master of the best drill methods and devices, and must be familiar with the important applications of arithmetic. In addition such a teacher must be acquainted with the work of the preceding years.

To meet these requirements the Teachers' Course in Arithmetic should include (1) A brief review of our decimal, place-value notation, of the four processes with integers and with common and decimal fractions, and of the fundamentals of percentage. As much drill should be given on all of these as time permits, making use of standard tests and standard drill devices. Methods of teaching fractions and percentage should be studied as these topics are reviewed. (2) A thorough study of the common applications of arithmetic including budgets and accounts, dealing with a bank, economy of purchase, savings and investments, taxes, the arithmetic of business, and the arithmetic of the farm. In each of these the understanding of the underlying social situations should be considered as being just as important as the ability to solve the arithmetical problem involved. (3) A study of the pedagogy of drill including laws of habit formation, methods of getting and keeping attention, methods of developing accuracy and speed, drill games and

devices, standard tests and standard drill devices. (4) A study of the pedagogy of problem solving including the purpose, nature and sources of problems, the psychology of problem solving, teaching pupils to solve problems and standard problem tests.

The geometry and algebra of the junior high school should accomplish two things. First it should give the pupils the directly practical portions of these subjects so as to complete the mathematical equipment of those pupils who pursue the study of mathematics no further. Second it should give all of the pupils a sufficient knowledge of these subjects to enable them to decide whether or not they have the inclination and ability to pursue them further in the senior high.

The Teachers' Course in Geometry should include the following (1) A study of the geometry of form including historical and present uses of geometric forms in architecture and in decorations, simple geometric constructions and the making of geometric patterns and designs, similar figures, ratio and proportion, and the construction of scale drawings. (2) The geometry of position including methods of locating a point and the making of plans and maps. (3) The geometry of size including the meaning and history of measurement; a consideration of the accuracy of numbers obtained by measurement and of results obtained in calculating with such numbers; methods of discovering and verifying the formulas for the areas, volumes and surfaces of the simple geometric figures; actual practice in using these formulas, the students making the necessary measurements; square and cube root including the use of tables; experimental methods of developing the Pythagorean theorem and other important theorems; applications of these theorems; field work including the direct measurement of angles and distances and indirect measurement by use of the isosceles right tirangle, scale drawings and similar triangles. (4) Graphical representation of statistics including the making and interpretation of bar, circular and line graphs. (5) Demonstrative geometry, including a consideration of methods of convincing pupils of the necessity for formal proofs. A study of the nature and form of formal proofs. (6) Standard tests.

The Teachers' Course in Algebra should cover the following: (1) The formula including the use of letters to represent quantities, making formulas from rules, stating formulas as rules and the evaluation of formulas. (2) The equation, methods of teaching the axioms, solving and checking simple equations.

(3) Methods of teaching pupils to use equations in the solution of problems. Methods of drill on algebraic representation and on the formation of equations to fit given conditions. (4) Negative numbers. Methods of showing the need for a new kind of number and of illustrating the meaning of negative numbers. (5) Methods of teaching the four processes with negative numbers and with algebraic quantities. (6) Methods of teaching factoring, fractions, simultaneous linear equations, the graph, and quadratic equations. (7) Standard tests.

One of the most essential parts of the student's preparation is the observation and practice teaching. This work should be done in the mathematic classes of a junior high school. An excellent plan is that of the University of Wisconsin by which the prospective teacher becomes a member of the class, prepares the lessons and participates in the class discussions the same as the other students, and is finally called upon to act as teacher. In any case, this work should be in charge of skillful teachers especially trained in mathematics and in junior high school work.

The training in mathematics beyond the portions to be taught, should include courses in trigonometry, college algebra, analytical geometry and calculus. In a three year course calculus would probably have to be omitted. These courses should, if possible, be given to groups of students all of whom are preparing to teach either in the junior or the senior high school and should be in charge of instructors who are themselves expert teachers and who have had some experience in the high school field. The mathematics needed by the prospective high school teacher and the methods of teaching best suited to such a student are not necessarily the same as that needed by and suited to the prospective engineer. All of the mathematics of the prospective teacher should be taken in classes in which the whole atmosphere is one of preparation for teaching as a life work.

The student should also be given a short course on the history of elementary mathematics. Such a course gives an appreciation of the subject a breadth of view and a background that can be gained in no other way. It also gives the prospective teacher much material that he can use in his own classes to create interest and to develop an appreciation for mathematics. The course should cover the history of arithmetic, geometry, algebra and trigonometry. In the history of arithmetic the following topics should be studied: old systems of notation, the Hindu notation,

methods of calculating on the abacus, old methods of calculating with the Hindu numerals, the history of the present methods of calculating, the history of fractions, old notations for fractions, old methods of calculating with fractions, the history of decimals, the history of percentage and the history of the development of the applications of arithmetic. The history of geometry should include a study of geometry before the Greeks, Greek geometry, Euclid's Elements, the development of solid geometry, the famous problems of elementary geometry, and geometry since the Greeks including a brief consideration of non-Euclidian geometries. The history of algebra should include a study of the development of the algebraic notation, the history of the solution of the equation and of the development of the number system of algebra. The history of logarithms and of the development of trigonometry should be briefly considered. If time permits the course might also include a study of the history of analytic geometry and of calculus. Having studied the development of the various branches of elementary mathematics the student as a review should trace its development from earliest times to the present by periods and by peoples. They should also trace out the two parallel streams of theoretical and practical mathematics.

Another condition that must be taken into consideration in planning a course of training for junior high school teachers is the fact that, except in the larger school systems, the teacher in the junior high school or the departmental teacher in the upper grades is usually required to teach more than one subject. Courses intended for the training of such teachers must, therefore, be planned so as to prepare the student to teach two subjects if necessary. The kind of mathematics that should be taught in the junior high school is probably more closely related to Industrial Arts than to any other subject and the mathematics teacher should be thoroughly acquainted with the work done in Industrial Arts even if that subject is taught by a different teacher. The course of training planned for the teacher of mathematics might, therefore, include enough work in Industrial Arts to enable the student to correlate the work in the two subjects or to teach the Industrial Arts as well as the mathematics when that is necessary.

In connection with the work in Industrial Arts the student should be given a course in shop mathematics. This course should do two things: (1) make the student familiar with eco-

nomical and labor saving methods and devices to be used in calculations, including abbreviated methods of multiplying and dividing, use of tables, logarithms, the slide rule and other calculating machines, and (2) give the student extensive practice in the applications of elementary mathematics to mechanical, industrial and shop problems.

In conclusion I am adding to my paper outlines for a four-year and a three-year course for the preparation of teachers of mathematics and industrial arts in the junior high school. These courses are planned in accordance with the suggestions made in this paper and are given here for the purpose of making these suggestions more concrete. They are tentative plans for courses that we hope to offer at the Bowling Green State Normal College as soon as there is sufficient demand.

A FOUR YEAR COURSE FOR THE PREPARATION OF TEACHERS OF MATHEMATICS AND INDUSTRIAL ARTS IN THE JUNIOR HIGH SCHOOL.

FIRST YEAR.

First Semester.		*Second Semester.*	
English Composition	2	English Composition	2
English Literature	3	English Literature	3
Trigonometry	4	College Algebra	4
Elements of Industries	2	Representative Drawing	2
Elementary Psychology	3	Shop Mathematics	3
Gymnasium	½	Gymnasium	½
	14½		14½

SECOND YEAR.

First Semester.		*Second Semester.*	
Analytic	4	Calculus	4
Shop Drawing	4	Shop Drawing	3
Wood Shop	2	Wood Shop	3
Educational Sociology	2	History of Education	3
School Hygiene	3	Principles of Teaching (Junior H. S.)	3
Gymnasium	½	Gymnasium	½
	15½		16½

THIRD YEAR.

First Semester.		*Second Semester.*	
Calculus	4	Industrial History	2
Educational Psychology	3	High School Administration (Junior H. S.)	3
Arithmetic and Methods	3		
Shop Drawing	2		

Elementary Design	3
	15

Geometry and Methods	2
Aims and Organization of Junior H. S. Mathematics	1
Pattern Making	3
Shop Sketching	2
Electives	2
	15

FOURTH YEAR.

First Semester.

Physics	4
Forge Shop	4
Sheet Metal Work	3
Algebra and Methods	2
Observation and Practice Teaching in Junior H. S. Mathematics	2
	15

Second Semester.

Physics	4
House Furnishing	3
History of Elementary Mathematics	2
Art Appreciation and History	2
Teaching of Industrial Arts	2
Observation and Practice Teaching in Industrial Arts	2
	15

A THREE YEAR COURSE FOR THE PREPARATION OF TEACHERS OF MATHEMATICS AND INDUSTRIAL ARTS IN THE JUNIOR HIGH SCHOOL.

(The first two years of this course are identical with the first two years of the four year course, except that the course in Arithmetic and Methods is substituted for the Calculus in the second semester of the second year.)

THIRD YEAR.

First Semester.

Shop Drawing	2
Elementary Design	3
Algebra and Methods	2
Observation and Practice Teaching in Mathematics	4
Forge Shop	4
Sheet Metal Work	3
	16

Second Semester.

Geometry and Methods	2
Aims and Organization of Junior H. S. Mathetics	1
Shop Sketching	2
History of Elementary Mathematics	2
Teaching of Industrial Arts	2
Observation and Practice Teaching in Industrial Arts	2
Art Appreciation and History	2
Electives	2
	15

MATHEMATICAL ERRORS SANCTIONED BY MODERN USAGE.

By G. A. Miller,

University of Illinois, Urbana, Ill.

In a review of Kowalewski's *Determinants*, published in volume 17 (1911) of the *Bulletin of the American Mathematical Society*, Professor Bôcher remarked, on page 139, that the only errors which he found in this book was the use of the word "determinant" frequently in the sense of "matrix." He added "this error is so sanctioned by universal usage that it must, for the present, be regarded rather as a defect of the age than of the individual." Teachers of mathematics are naturally greatly interested in errors relating to their work which are now sanctioned by universal usage in order that they may direct their students aright as regards these particular pitfalls.

Some readers may be inclined to raise the question whether Bôcher was correct in this criticism. This question seems the more natural since Kowalewski wrote one of the best books on determinants in existence and is now one of the prominent German mathematicians. One might think he ought to know what the term "determinant" means, if any one does. On the other hand, it is well-known that Professor Bôcher was a very eminent American mathematician who had published a standard work on higher algebra before he wrote the review under consideration, and he, too, ought to know the meaning of such a common term as "determinants." Moreover, since Bôcher criticized Kowalewski's use of this one term it is likely that he gave more attention to this particular item than Kowalewski had done.

The so-called error in question can clearly not be proved to exist by means of a mathematical demonstration. Those errors which have been thus proved to exist are no longer sanctioned by modern usage. The mathematician has to deal with some errors which cannot be disposed of in such an easy manner. What Professor Bôcher probably desired to emphasize is the fact that there is a wide difference between the concept of determinant and that of matrix, which was not clearly exhibited in the otherwise excellent work which he was reviewing. In view of the great importance of this difference he felt justified in calling this lack of clearness an error.

What may surprise some readers is the fact that such a noted mathematician should have claimed that there exists now in the mathematical literature any error which "is so sanctioned

by universal usage that it must, for the present, be regarded rather as a defect of the age than of the individual." It often takes considerable courage to affirm that an individual has committed an error, but it evidently takes more courage on the part of one who has a reputation at stake to affirm that a particular error is sanctioned by the mathematical writers of our age, even if this charge is less personal. Such a charge should, however, encourage the student of mathematics to think for himself and not to depend too much on what leading authorities have stated as regards fundamental questions. Some of these questions cannot be decided by citing references.

The young mathematician should not feel too confident that he is able to dislodge at once an error which is strongly intrenched. Just as the poor Polish mathematician, H. Wronski, was unsuccessful in receiving immediately strong support when he directed attention to errors committed by the eminent J. L. Lagrange as regards expansions in Taylor's series, so now the sympathy is apt to be at first with those who have secured a wide reputation. This misplaced confidence is, however, not apt to be permanent. In fact, in the case under consideration it was later made clear that in this particular Wronski was right and that the far more noted Lagrange was wrong.

The preceding remarks are intended to serve mainly as a setting for the consideration of a common definition of the term equation as a *conditional equality*. Several years ago my attention was directed to this definition by the following statement: "The expression $2+5 = 7$ expresses an equality, but is not an equation as the word is technically used in mathematics." This statement appears near the beginning of the article on equation in the second edition of the *New International Encyclopaedia*. The view here expressed is supported by the definition of equation which appears in the *College Algebra* which we have been using at the University of Illinois for a number of years.

In using this textbook I have often been perplexed as regards what to say to the students in reference to this definition. In my private copy I wrote the word "nonsense" on the margin adjoining the definition in question, but I have usually presented my views to the students in a milder form by telling them that some of the best authorities called an expression of the form $2+5 = 7$ an equation and that I saw no good reason why this should not be done. It seems to me that the student would naturally call such an expression an equatoin and that it is artificial to require that a symbol for an unknown or variable must appear in an equation.

It would, perhaps, be too strong to say that those who insist on such a symbol in an equation commit an error which is sanctioned by modern usage, but anything that introduces unnecessary distinctions as regards such a fundamental term is serious in its total effect. The student of mathematics meets with so many really interesting facts that he has no time for unnecessary distinctions. He should, of course, be led to see the difference between conditional equations and identities, or unconditional equations; but both of these forms should be known by the fundamental term, equations. Many of the best American and foreign authors have expressed themselves in accord with this view.

It is probably a good thing to direct, at an early age, the attention of the mathematical students to the fact that some mathematical terms are used with different meanings by different authors. While the mathematical language is the most accurate among the scientific languages it is not yet perfect. In fact, as long as our subject is growing its language cannot be expected to become perfect. While the young student usually prefers definite and conclusive statements it is desirable to let him see that even in such an exact science as mathematics there exist differences of opinion relating to some elementary questions. Such instances as those noted above may thus be made to serve a useful purpose on the part of teachers who are anxious to develop a clear view as regards to nature of their subject.

We used above, in accord with modern custom, the terms "unknown" and "variable" for the symbol which appears in a conditional equation. It may be added that the concepts denoted by these terms are usually very different. The term variable is frequently used in the theory of equations for something which does not vary just as the term constant is often used for something which is supposed to vary, as is the case when it is used in the sense of a parameter. Such things as constant variables and variable constants are not uncommon in the mathematical literature but they seldom lead to confusion, as the context will generally exhibit clearly what interpretation is to be given to the terms. Our main objects as regards the present note are to emphasize the facts that the best modern authorities may disagree with respect to details relating even to some elementary points in mathematics and that identities are equations while equations are not necessarily identities.

A LOOK INTO ONE'S EYE.

By Hiram W. Edwards,

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There is no more wonderful optical instrument than the human eye. When one considers the extraordinary sensitiveness to light of different colors, the automatic regulation of the pupil, the sense of perspective afforded by the dual point of view, the remarkable ability to recover from abuse, and when one compares it to man-made optical instruments, he is likely to agree to the above declaration. It is the purpose of this article to present some suggestive material which has been collected to supply our students with opportunities to learn more about this wonderful organic mechanism, so that they may appreciate its fineness. There is, however, more to be gained than appreciation, especially by those students who have selected medicine or physiology for their life work. For such students an accurate knowledge of the underlying principles and their application is very necessary.

The needs of pre-medical students were in mind when the following material was organized. The work given here may be regarded as a typical part of the content of a course in physics for pre-medical students. It presupposes a working knowledge of the optical principles and shows how these principles may be associated directly with the information they require. An extension of this work could easily lead to a field that has been but little discussed in published articles—namely, Bio-Physics.

The work below may serve as a basis for presenting three units or problems for laboratory work. Briefly it consists of a physical and anatomical study of a pig's eye, a representation of normal and abnormal conditions of vision in the human eye by a physical model and a measurement of the curvature of the cornea of the human eye for the detection and correction of astigmatism.

Study of the Pig's Eye. The object of this study is to present material so that when measurements are taken of the various physical constants and the relative positions of parts, an excellent representation of the human eye will be obtained. Pigs' eyes may be easily obtained from a slaughter house. They must be fresh because decomposition will speedily make accurate measurements difficult. The cornea rapidly becomes cloudy and the suspensory ligament which holds the lens in place, on decomposition, permits a mixing of the vitreous with the aqueous

humor. The supply of eyes should be kept on ice and even then in two or three days will have depreciated in value.

The procedure which is recommended consists of an external measurement, including over all dimensions and radius of curvature of the cornea, qualitative inspection of image formation on the retina, a dissection from which inner distances between parts on the axis may be measured, determination of the index of refraction of the two humors, and finally a measurement of the focal length of the crystalline lens. A brief description of some of these processes may be of interest.

In order to see the image formation on the retina, a small opening, about 5 or 6 mm. square, may be cut in the upper part of the eye through the sclerotic and choroid membranes into the vitreous humor. If the eye is held gently the humor will not run out and when a piece of thin glass is placed over the opening there is provided a window through which the images on the retina may be seen. An electric light will serve excellently for the object if held a few inches from the eye on the optical axis.

To measure the index of refraction of the vitreous and aqueous humors various methods may be used, but very little of either fluid is available hence a selection of method is necessary. The minimum deviation method as it is ordinarily used with a prism is serviceable in this case. There is required for this measurement a spectrometer and a small hollow glass prism, made of thin glass walls and having a small angle. Such a prismatic tank may be easily constructed from microscope slides cut to appropriate size and cemented with sealing wax. It has a defect, however, in that such glass is not optically flat, but is nevertheless sufficiently accurate for the present purpose. Even though only two or three cubic centimeters will suffice to fill the tank, it will be necessary to extract the aqueous humor from several eyes, for only a couple of drops occur in each.

The focal length of the crystalline lens is very short, especially when measured in air. In order to determine this constant with even a fair degree of accuracy, it will be found expedient to measure the focal length of the lens when immersed in water. This device has the double advantage of giving a much greater distance and incidentally the index of refraction of water is very nearly equal to the indices of the humors. Hence only a slight correction will be found necessary.

A sectional diagram of the eye, drawn to a magnified scale, will be very useful in assisting the student to visualize the effect of

the various parts upon the image formation. For this purpose the paths of light rays coming from one or more external points on the axis may be computed. If it is desired to stimulate interest by stating the object of the work in problem form, the student may be asked to find the point on the axis which is conjugate to the point where the axis enters the retina.

A Physical Model of the Eye. To present to the average student material which is designed to give an adequate picture of the defects of the eye and their corresponding corrections, there is evidently nothing more serviceable than a working model large enough to permit comfortable manipulation. Kuhne's model has been found very satisfactory for this purpose. Dr. Minor, of the University of California, at Berkeley, has modified this to considerable advantage (See *Minor-Physical Measurements. Part IV*). It was found, however, more economical to design a tank which could be used for other purposes as well. This tank was made from square brass tubing (15x3x3 inches). One side was almost completely removed for the top, and an adjacent side was replaced by plate glass. In one end was mounted a suitable support so that various types of spherical glass shells or lenses could be readily put in place. A spherical shell having a radius of about 5 cm. served to represent the cornea. Immersed in water in the tank there could be suspended any desired lens for the crystalline lens and an enamelled screen for the retina, each in its appropriate position.

When it was desired to represent an emmetropic or an ametropic condition, the retina could be moved or the crystalline lens could be replaced by another or different focal length. Corrections could then be made by slipping spectacle lenses, converging or diverging as desired, in front of the cornea, in much the same way that the optician does with his test lenses.

Astigmatism was represented by replacing the normal spherical cornea by a "cylindrical" lens. The direction and amount of this defect could be measured by using converging or diverging cylindrical lenses. In this case the actual path of the rays should be made luminous by adding a few drops of a dilute solution of common rosin in alcohol, in order to visualize the nature of the defect.

Obviously for this work many lenses of different values are necessary. These were gratuitously supplied by local opticians from their piles of discarded lenses. Several thousands were donated upon the request of the Department of Physics, from

which were selected and classified those needed to make the test sets. Only those were used which were not combinations of spherical with "cylindrical" curvatures. These four sets of test lenses were arranged as the optician arranges them, i. e., by steps of a quarter of a diopter. Even the terminology was retained in order to introduce the student to the diopter as a unit. To aid in this classification the "lens measurer" was indispensable. Incidentally, this is a very valuable instrument to have in the laboratory. Though graduated in diopters it may be used as a spherometer if a radius of curvature-diopter curve is prepared for it. It bears the same relation to the peg and ring spheromoter that the automatic balance does to the trip scales.

The optical tank described above has other valuable uses in the laboratory and it may be worth while to mention them here even though it be a digression from the subject under discussion. By doing so a little economy may be encouraged. With the crystalline lens removed from the tank and the spherical cornea of 5 cm. radius of curvature in place, there is needed only an electric light to supply all of the necessary materials for determining the conjugate relations between object and image distances which exist in the very interesting case of refraction occurring at a single refracting surface. (See *Minor-Physical Measurements.*) Obviously the lamp may be used as the object or it may be used to illuminate a screen to serve as the object. The object may be in air or water as desired. The focal length of the refraction surface depends upon the direction of the light.

The effect of the medium upon the focal length of a glass lens may also be determined if a piece of plane glass is used in place of the spherical cornea.

Measurements upon refraction occurring between air and water or the reverse may be made when light enters or leaves the plate glass side of the tank. A beam of reflected sunlight serves advantageously here. A determination of the critical angle may be made in this connection.

Astigmatism in the Human Eye. The following idea was borrowed from an observation of the ophthalmometer as used by opticians. This instrument is a little complicated but is used to determine the curvature of the cornea in different planes passing through the optical axis of the eye. If the anterior portion of the cornea is essentially symmetrical, and approximates a spherical surface, the eye suffers no astigmatism. But if there is a departure from this symmetry, which means that the radius of curva-

ture is not the same in all planes, then astigmatism results.

To measure this distortion, use may be made of the well-known optical method for measuring the radius of curvature of a reflecting surface. This consists essentially of measuring the distance between the images by a moving telescope. Other measurements are necessary, such as the distance between the two luminous points, and the distance from the light sources to the reflecting surface. The relation between these distances may be readily determined.

When applied to the measurement of astigmatism, a special mount must be provided which carries the telescope on the axis and permits the two lights to be rotated about the axis. If measurements of the cornea-radius are made in several positions then the axis and the amount of the astigmatism may be determined. Students evidence considerable interest in this work and it may be concluded that they gain thereby a fairly comprehensive idea of the nature of the astigmatism and its corrections.

Theoretically, it is possible to measure with this apparatus the change of the radius of curvature of the anterior surface of the crystalline lens as the eye focuses first on the near object and then on a distant one, but practically there is a difficulty in holding the eye sufficiently stationary to permit of the measurements. However, it is very instructive and interesting to observe the change in the distance between point images formed by reflection, from the anterior lens surface, for in this change lies the ability of the eye to change its refracting power and to bring into sharp focus the image of objects situated at different distances from the eye. A little skill, however, is required to locate the desired pair of images, for each of the three reflecting surfaces, cornea, anterior and posterior lens surfaces, form a pair of images. The pair formed by the cornea is most prominent. The one formed by the anterior lens surface is fainter than the corneal image and brighter than the one formed by the posterior lens surface. In fact the images formed by the posterior lens surface are hard to find because of their faintness. These last mentioned images are inverted because of the concave surface, while those formed by the cornea and anterior lens surface are erect. The reader who is interested should consult Edser's book on "Light for Students" in which he will find many valuable suggestions.

WHAT SHALL WE TEACH ABOUT CHEMICAL EQUILIBRIUM?[1]

By Forrest W. Cobb,

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Shall we teach chemical equilibrium?

My purpose is to develop our topic for today as it may be developed with a first year class in chemistry and incidentally to give some easy demonstrations. A survey of various high school text books shows that this important topic is rarely given adequate treatment. It is well worth while to read what Alexander Smith has written on the teaching of this subject.[2]

"Chemical Equilibrium cannot be counted amongst the new developments of theoretical chemistry, for its beginnings were coeval with the discovery of oxygen and its principles clearly understood forty years ago or more. A strange reluctance, however, has been shown in regard to the recognition of its laws, both by investigators and instructors in chemistry. The blunders which have been made through failure to pay attention to them are only too familiar. The importance of these principles in explaining many of the commonest chemical changes may well awaken surprise at this strange neglect. The class of actions in which they find their chief application and which must be *misunderstood* without recourse to them, namely, reversible reactions, form a majority of the changes which the pupil encounters in elementary chemistry. The contrary statement which one so often sees, is so palpably incorrect that one can but wonder what limitation the author was thinking of when he made it. The Brin method of preparing oxygen by means of barium peroxide and the chemical decomposition of mercuric oxide furnish examples at the very outset. Most of the chief changes at the beginning of the course are reversible, and the actions of this class predominate more and more as the course progresses. Whether it is judicious to point this out to the pupil, or to discuss the consequences of the fact may be a matter for discusson. But there can be no question that if the teacher is not familiar with this fact, and with the whole subject, he is likely to fall into egregious blunders, such as stating that sulphuric acid is stronger than nitric acid, and enunciating quasi principles of a misleading kind, like the so-called principles of precipitation or volatilization. Almost the only way to get clear ideas on this subject is to read the treatment of it in several different books, and to make some experiments illustrating the principle of chemical equilibrium for one's self."

[1]Prepared at the 1923 session of the Harvard Summer School for Education SM6, "Problems in Teaching Physics and Chemistry."

[2]Smith and Hall, p. 169. (Pub. 1902.)

Reversible reactions deal with chemical equilibrium.

The idea of reversible reactions comes up a number of times in the course before we consider equilibrium. Two common illustrations of reversible reactions are these:

$$CO_2+H_2O \rightleftharpoons H_2CO_3$$

$$NH_3+H_2O \rightleftharpoons NH_4OH$$

When we pass carbon dioxide into cold water, carbonic acid is formed, but by applying heat the carbon dioxide may be driven off and leave only the water behind. We understand from the double arrow that the reaction may proceed in either direction according to the conditions. Then later when we go into the subject of solutions and ionization, we find that not all of the dissolved molecules are ionized except in very, very dilute solutions. The process of ionization is reversible and the degree of ionization depends on the compound used, the concentration of the solution, the temperature and so forth.

Types of complete reactions.

We found that all double decomposition reactions which go to completion, go for one of three reasons:

1. A gas is given off:

$$CaCO_3+2\overset{+}{H}\overset{-}{Cl} \longrightarrow \overset{++}{Ca}\overset{-}{Cl_2}+H_2O+\overset{\uparrow}{CO_2}$$

2. A precipitate is formed:

$$\overset{+}{Ag}\overset{-}{NO_3}+\overset{+}{H}\overset{-}{Cl} \longrightarrow \overset{+}{H}\overset{-}{NO_3}+\underset{\downarrow}{AgCl}$$

3. One product of the reaction does not ionize:

$\overset{+}{H}\overset{-}{Cl}+\overset{+}{Na}\overset{-}{(OH)} \longrightarrow \overset{+}{Na}\overset{-}{Cl}+H_2O$. In any case, ions are removed from the reaction.

All these things which have been taken up earlier in the course should be made clear and definite in the minds of the pupils before we begin on chemical equilibrium in earnest.

Experiments about mass action.

Now, I have three experiments illustrating mass action, and for the first one, let me attempt a complete explanation in terms of ions and molecules. Here we have a bottle with some water in it. The water consists of rapidly moving molecules, continuously in motion. Some of them break away from the surface and change to the vapor state. Now as soon as the water was put into the bottle, the molecules started breaking away from the surface at a definite rate depending on the temperature and pressure. As soon as molecules existed in the vapor state, some of them tended to, or rather, *did* form water in the liquid state and

the rate at which they formed water gradually increased until water molecules changed into vapor and vapor molecules changed into water at exactly the same rate. When this condition exists, we have a state of equilibrium and I wish to bring out three characteristics of such a state.

The Characteristics of a State of Equilibrium[3] *are:*

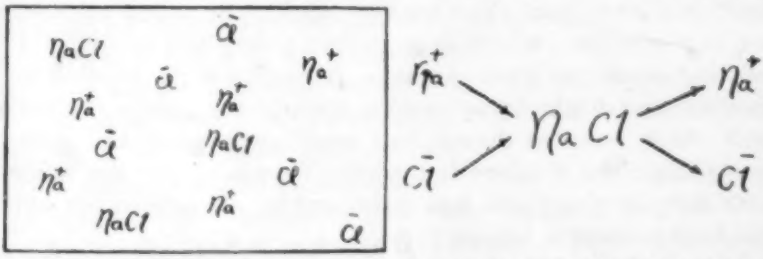
1. There are always two opposing tendencies.
2. At equilibrium, both tendencies are in full swing.
3. A slight change in conditions produces only a slight change in the system.

Equilibrium is dynamic.

In order to make clear that at equilibrium, both tendencies are in full swing, we can consider the analogy of a pond which always contains the same amount of water though water is flowing in and out of it all the time. The two opposing tendencies we would be considering here would be the tendency to fill and the tendency to empty. (A lecture table demonstration might be used to illustrate this.) To illustrate the effect of a slight change in conditions, we can compare with a pair of pan balances. Making a slight change in the weight in one pan makes but a slight change in the position of the pans. When we raise the temperature of this bottle, the molecules become more active and leave the liquid faster. This causes more molecules to exist in the vapor state. A slight change in temperature causes a slight change in the state of the system.

Equilibrium in a common salt solution.[4]

I have in this flask a saturated solution of sodium chloride. In here we have a state of equilibrium between the sodium chloride solid and the salt molecules in the liquid. We also have



a state of equilibrium existing between these molecules and the sodium and chlorine ions. Now let us keep in mind that the solution is just balanced and any increase in the concentration of sodium chloride molecules is going to cause solid salt to separate out. I will filter and obtain a clear solution separated from the solid. We can represent the conditions in the solution something like this:

At any given instant there will be some unionized molecules

[3] Cf. Kendall, Slosson, p. 69.
[4] Cf. Black and Conant, p. 230.

and some molecules broken up into sodium and chlorine but the number of sodium ions is always equal to the number of chlorine ions. Here is a concentrated solution of hydrochloric acid in which the following condition exists: $HCl \rightleftharpoons H + Cl$.

When I add a few drops of this clear liquid to the clear saturated salt solution, we get a white solid separating out. What has happened? When we put the hydrochloride acid into the solution we increase the total number of chlorine ions and the positive sodium ions meet the negative chlorine ions more frequently so that sodium chloride molecules form faster than the water can take care of them and some separate out as solid. . . . If this is the true explanation, we can go one step farther and add to some of our saturated solution a solution which will increase the concentration of sodium ions. Let us add some of this sodium hydroxide solution and see what happens . . . . . Yes, we have this white solid separating out again. Sodium ions are present in greater numbers and therefore chlorine ion meets sodium ion more frequently than in the staurated NaCl solution. The NaCl molecules are formed more rapidly so that the state of equilibrium between NaCl solution and NaCl solid is displaced and some salt separates out in the solid form.

Direction of action indicated by change of color.

There are other experiments which may be used to illustrate this phenomenon. One depends on this reaction:

$$3NH_4CNS + FeCl_3 = 3NH_4Cl + Fe(CNS)_3.$$

The ferric sulpho-cyanate as you all know, is a red solid which is soluble in water. Now I'll take about five cubic centimeters of each of these two solutions (NH_4CNS and $FeCl_3$) and mix them in a large flask. You see that my slightly yellow solution and my colorless solution have formed a deep red solution. I will add about two liters of water. This dilutes the solution so that we can tell which direction the reaction has gone in. If our pink shade becomes deeper, our equilibrium point has gone toward the right, if paler—to the left. We will fill four test tubes with our pale pink liquid, and saving one for comparison, we will add to the others as follows:

First test tube. Five cubic centimeters of NH_4CNS solution makes the solution redder. (We have increased the concentration of CNS^- ions, Fe^{+++} ions meet them more frequently; consequently the action goes to the right.)

Second test tube. Five cubic centimeters of $FeCl_3$ solution makes our solution redder because the number of Fe^{+++} ions

per cubic centimeter has been increased and the reaction goes to the right.

Third test tube. Fifty cubic centimeters of saturated NH_4Cl solution pushes the reaction in the other direction and the solution becomes paler.

Experiment using a basic salt.

The third reaction which I shall use to illustrate this principle is this: $BiCl_3+H_2O \leftrightarrows BiOCl+2HCl$. When we have a white precipitate, we know that the reaction has progressed toward the right, when we have a clear solution it has gone to the left. By adding about 20 cc. of saturated bismuth trichloride solution to 50 cc. of water, we get a white precipitate, bismuth oxychloride. Now by alternately adding $H \leftarrow Cl$ and $H_2 \rightarrow O$, we can have the reaction go in the directions indicated and procure alternately a clear solution and a dense white precipitate. ($SbCl_3$ may be used instead of $BiCl_3$).

This leads us to the law of concentration or mass action: *"By increasing the concentration of one of the reacting substances or decreasing the concentration of one of the products, we may cause a chemical action to go more nearly to completion in a given direction."*

Other illustrations.

In concluding, since each demonstration has treated a case where an increase in the concentration of a substance has *pushed* a reaction in one direction or the other, let us use as our first illustration for drilling the class a case where a decrease in the concentration of a substance *pulls* the equilibrium point in a given direction. One of the best illustrations of this is the equation

$$3Fe+4H_2O \leftrightarrows Fe_3O_4+4H_2.$$

When steam is being passed over hot iron, the stream of steam carries the hydrogen formed away and when a stream of hydrogen is passed over hot magnetic iron oxide, the stream of hydrogen carries the steam formed away. So the reaction keeps on going in either direction until iron or iron oxide, as the case may be, is wholly converted.

Another important illustration of this is the bleaching reaction $Cl_2+H_2O \leftrightarrows HOCl+HCl$. The oxygen in the HOCl is used up by the dyestuff and only HCl remains. It is well to illustrate by a number of familiar reversible reactions.

SOLUTIONS USED.

NaCl	Saturated
HCl	Sp. Gr. 1.20
NaOH	Saturated

NH_4Cl ..... Saturated

$FeCl_3$ ..... { Com. (basic) Ferric Chloride 6 gm.
Conc. HCl 25 cc., Water to make 200 cc.

NH_4CNS ..... { NH_4CNS—7.5 gm.
Water to make 200 cc.

$BiCl_3$ ..... { $Bi(NO_3)_3$—40 gm.
Conc. HCl—40 cc.

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NEW RAY DISCOVERED IN ATOMIC COLLISIONS.

Discovery of a new and rare sort of rays resulting from partial disintegration of atoms as a result of collisions with alpha particles, the nuclei of helium atoms, moving at a speed 30,000 times faster than a rifle bullet, was announced to the American Chemical Society meeting in Milwaukee by Prof. W. D. Harkins and R. W. Ryan, of the University of Chicago. The discovery was made as the result of 41,000 photographs of atomic collisions.

The new rays which have been named "Zeta rays" by Professor Harkins are very short and are thought to be due to electrons knocked out of atoms through which the flying alpha particle speeds. He also considers it possible that they may be due to electrons picked up by the alpha particle and then discharged from it. They move in parallel tracks and in a direction nearly opposite to that of the impinging alpha particle.

Professor Harkins' paper was illustrated with photographs and motion pictures of the atomic collisions. Although atoms are a thousand times too small to be seen by the highest powered microscopes and the electrons are many times smaller it has been found that water vapor will condense on them and that these minute droplets may, if strongly illuminated, be made visible in the microscope. The moving nuclei and rays thus leave behind them a wake of light which appears in the pictures as a fine white line.

The alpha particles or helium nuclei, with which the atoms of air were bombarded, were obtained from disintegrating radium "C", which shoots them out with a velocity comparable to that of light. Each atom of air, like other atoms, consists of a nucleus and a surrounding system of electrons, similar to the sun and its planets. When a moving alpha particle passes through an atom it may or may not come into collision with a central nucleus or one of the electrons. Collisions with electrons are relatively common; those with a nucleus are very rare. When this happens the atom is smashed up beyond recovery. Many photographs of such crashes were shown by Dr. Harkins.

"What the importance of these rays may be, it is impossible to say," Dr. Harkins declared, "since they are so new that their characteristics are still unknown. "They should give some new light on the structure of atoms, the emission of electrons from them, and of the nature of the electromagnetic fields of force in the vicinity of the atom. A more thorough knowledge of these fields of force should lead to important discoveries and inventions in the fields of chemistry and of physics."—[*Science Service.*

FINAL EXAMINATIONS

By Wm. Asker,
Joliet Township High School and Junior College.

Mathematics.

Swedish Real-Gymnasium, Fall Semester 1922.

1. What is the sum of the first n terms of the series

$$1-2+3-4+5-6+7- \quad \cdot \cdot \cdot \cdot \cdot \cdot \ ?$$

2. From an outside point tangents are drawn to a circle of radius r. In the circle a rectangle is inscribed that has one corner in each point of tangency, and one side equal to the radius. Give the distance from the outside point to the periphery of the circle for the two cases that may occur.

3. In a rhombus the sum of the diagonlas is $= s$, and one of the angles is $= v$. Prove that the area of the rhombus is $=$

$$\frac{s^2 \sin v}{8\cos^2(45^\circ - \tfrac{1}{2}v)}$$

4. A debt of 10,000 crowns is paid off during a period of years in such a way that every year 300 crowns is paid at the end of the first half year, and 500 crowns at the end of the second half year. How much remains of the debt after 17 years, if interest is computed at 4 per cent compounded semi-annually?

5. Determine the angles A, B, and C of a triangle, if

$$\left.\begin{aligned} 2\sin A + \sin B - 2\sin C &= 0 \\ \sin A + 3\sin B - 3\sin C &= 0 \end{aligned}\right\}$$

6. From the center of a regular tetrahedron straight lines are drawn to two corners of the tetrahedron. Find the angle between these two lines.

7. In an ellipse that triange is equilateral whose corners are situated at the center of the ellipse and at the end points of the parameter. Find the eccentricity of the ellipse.

8. The vertex of a parabola is at the center of an ellipse of eccentricity 4/5, and its focus coincides with one focus of the ellipse. Determine the angle under which the two curves intersect.

9. On the hypotenuse AB of a right triangle ABC a square is drawn away from the triangle. Show that the straight line that connects C with the center of the square divides the triangle in two parts that are in the ratio $AC : BC$.

Physics.

Swedish Real-Gymnasium, Fall Semester 1922.

1. A vessel in the shape of a rectangular prism whose inside edges are 1 dm., 2 dm., and 3 dm., is closed except in one of the corners, where there is a small opening. Through this opening a certain amount of water is poured whereafter the opening is closed. If the vessel is placed horizontally on one of its smallest surfaces as base, the sum of the pressure of the water on the bottom and on the sides is 2.7 times as great as if the vessel is placed on one of its largest surfaces. How much water does the vessel contain?

2. A body is thrown with a certain initial velocity up a rough inclined plane. The plane slopes 30° to the horizon, and the coefficient of friction is 0.2. How many per cent of its original kinetic energy has the body lost when it returns to the starting point?

3. The quantity of heat that through conduction passes through a window pane may be considered proportional to the difference between the temperatures on the inside and on the outside of the glass, and may for a certain thickness of glass be estimated at 0.002 gram calories per second for each sq. cm. of surface at a difference in temperature of 1°C. How many kilograms of coal must be burnt to produce the same quantity of heat as is conducted through a combined window area of 10 sq. meters, when the inside temperature is +15°C. and the outside temperature −10°C. during 24 hours? The combustion of one gram of coal gives 6,000 gram calories.

4. The upper end of a vertical string is fastened to a fixed point, and its lower end to a straight one-armed lever (fulcrum at one end). The string is stretched partly by the weight of the lever itself, and also by a weight suspended from the lever. If this weight is hung at the center of the lever, the string gives, when it swings transversally, the tone A. If the weight is moved 10 cm. to one side, the string gives the tone g. Where must the weight be attached in order that the string may give the tone h?

5. A sphere of glass rests on a horizontal table and is struck by the rays from the sun. A real image of the sun is thereby projected on the table. What angle do the incoming sun rays form with the horizontal plane? The index of refraction for the glass is 3/2.

6. Two unknown resistances m_1 and m_2 are inserted, one in each branch of a Wheatstone's Bridge. The galvanometer shows zero when the part of the scale wire that is nearest the resistance m_1 is 57.1 cm. The length of the scale wire is 100.0 cm. A re-

sistance of 10 ohms is now inserted in series with m_1 and the contact point must be moved 9.8 cm. from the first position in order that the galvanometer shall again point on zero. Compute the two resistances m_1 and m_2.

7. A battery of three storage cells, each with an EMF of 2 volts and an internal resistance of 0.1 ohm, is closed by an external wire of 7.7 ohms resistance. The negative pole of the battery is grounded so that its potential is zero. It is also connected through a wire of 1 ohm resistance with a point A on the outside circuit. It is desired that the potential at A shall be exactly 1 volt. Where must A be situated?

8. Describe some methods of determining the humidity of the air.

Swedish Latin-Gymnasium. Fall Semester 1922.

1. How many terms of the series

$$1+3+5+7+ \quad . \quad . \quad . \quad . \quad .$$

must be included in order that the sum may be 1,234,321?

2. In a trapezium $ABCD$ the parallel sides AD and BC are 8.2 and 5.4, respectively. The side CD is 6.3, and the angle ABC is 58.6°. Compute the side AB.

3. Solve the equation

$$(x+1)^5 = x^5+1.$$

4. The total surface of a regular pyramid is three times the area of the base. Find the angle that is formed by one lateral surface with the base.

5. A triangle in which the vertex angle is one-half of each of the base angles, is divided into three triangles by straight lines from the point of intersection of the altitudes to the three corners. Find the ratio between the smallest of these triangles and one of the others.

6. A person has a debt that he may pay either through three equal instalments of 4000 crowns at the end of one, two and three years, or by paying 12,800 crowns at the end of the third year. At what rate of interest will the two methods be equally advantageous?

7. Determine through graphical construction the values of x for which the two functions

$$y = x^2-2 \text{ and } y = \log_{10}x.$$

have the same value.

8. A ray of light, emanating from a point A, is reflected by a plain mirror to a point B whose distance from A is 5 m. The points A and B are at distances 8 m. and 4 m., respectively, from the surface of the mirror. Compute the angle of incidence under which the ray strikes the mirror.

WASHINGTON STUDENTS PAY THEIR OWN WAY.

More than five-sixths of the men students at Washington State College have earned or are earning part or all of their expenses. In replies to a questionnaire addressed to 1,374 students on this subject, only sixteen per cent were reported as not taking some part in earning their way through college.

In reply to the question, "Did you earn money which brought you to school?" nearly half of the men replied that they had earned all of it. Eight per cent of them had earned two-thirds of this money, thirteen per cent had earned half of it, and twleve per cent one-third of it.

Thirteen per cent of the students expect to earn their entire expenses during the school year, eight per cent expect to earn two-thirds, and fourteen per cent expect to earn half of them.—[*School Life.*

WHAT MAY REASONABLY BE EXPECTED OF THE HIGH SCHOOL TEACHER OF GEOGRAPHY.[1]

By V. I. Brown,

Principal, Community High School, Watseka, Illinois

Before we can determine what we may reasonably expect of any teacher, it is necessary that we know two things; first, the conditions under which the teacher works; and second, something of the teacher herself. Unfortunately, accurate information on these points is difficult to obtain, as no one seems to have made a careful study of either. Nevertheless, there are some few conditions which seem to be generally admitted without contradiction. Geography in the elementary schools is usually begun in the fourth grade and discontinued (not completed) in the seventh grade. Perhaps six per cent of the recitation hours of the elementary school pupil is given to this important subject. In Illinois, twenty to thirty per cent of the *secondary* schools do not offer the subject at all. When offered it is almost uniformally a one-semester elective, and may be placed anywhere from Freshman to Senior year, inclusive. No data on the number of pupils taking the subject seems available in this state, but Miss Elizabeth Dunbar found that "of all schools in the State of New York having over one thousand pupils (only) five per cent of the total enrollment are in geography classes."[2] Mr. Fleming Cox, in 1918, found that geography in Illinois was being taught in almost every possible combination with other subjects.[3] Some of the more incongruous of these combination subjects were Latin, French, military drill, spelling, penmanship, domestic science, manual training, stenography, and typewriting. Perhaps Illinois is behind her sister states in recognition of the worth of this subject but there is no evidence that conditions are markedly better in other states. Professor Whitbeck, of the University of Wisconsin, in 1914 declared that ninety per cent of the students who enter Normal Schools and Colleges are deficient in even the elements of general geography, and in 1919, Dr. J. Paul Goode, of the University of Chicago, asserted "Geography teaching is at a low ebb—the pupil goes into his life work with as nearly nothing in geographical training as can be imagined."[4]

The late war did something to emphasize the need and increase

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[1]Read before the Geography Section of the C.A.S. & M.I., at the Hyde Park High School, Chicago, December 1, 1922.

[2]Journal of Geography, October, 1922.

[3]Proceedings of High School Conference, 1918.

[4]N.E.A. Proceedings, 1914 and 1919.

the interest in the subject and the increase in the circulation of the National Geographical Magazine indicates a growing interest among educated people, but the change has not been so pronounced as to give occasion for great hope of future development.

Geography has been specialized, industrialized, humanized, vitalized, socialized, visualized, and localized. The net result of all of which seems to be that it is still in the process of being ostracized.

So much, briefly, as to the conditions, and now for the teacher. Should you have the feeling that this paper is written largely from the viewpoint of the smaller high school, I call your attention to the fact that the small high school is, after all, perhaps, the biggest problem in secondary education. Forty-five per cent of all secondary pupils in accredited high schools in this state are enrolled in high schools of less than five hundred, and twenty per cent in high schools of less than two hundred. If you exclude the city of Chicago, the per cents are sixty-five and thirty respectively. These figures do not include private and parochial schools, nor some 350 unaccredited public schools, the latter alone enrolling approximately 12,000 pupils. A school of less than 500 can hardly employ a special teacher of geography. The result is that geography is being taught by a group of teachers whose chief interest is in other fields, frequently not scientific. These teachers for the most part are young men and women—mostly women—of less than twenty-five years of age, who have had less than three years of teaching experience. To expect a broad social or industrial viewpoint in such young people is to expect the unreasonable. These conditions are presented not to depreciate this most vital and interesting subject, but only in an attempt to be fair in our demand upon the teacher.

What, then, may we reasonably expect of those teachers of geography? Let us approach the answer from the negative side by first stating what we cannot expect. We cannot expect trained geographers as teachers. The demand for trained geographers in other lines is sufficient to take all available material. With the exception of a few of the large city schools, we cannot even expect teachers who are specially trained as geography teachers. This is due to two things: first, the fact that geography is taught in connection with other subjects which usually require more time and enroll more pupils, which tends to pre-

vent specialization in this subject; second, there are no schools training such teachers. Granted that our Normal Schools are offering courses tending to prepare such teachers, their graduates are not going into our high schools, at least, not until after completing a college or university course. Granted also that our colleges and universities offer courses in this subject, these courses are not specially adapted to teachers' needs and the evidence indicates that those young people who take the courses do not become teachers. Of 225 pupils now taking the course in geography at the University of Illinois, only fourteen are majoring in the subject, and eleven others list geography as their minor subject. Thirty-five expect to teach geography, but ten of these expect to teach in high institutions of learning. Under such conditions, geography teachers can hardly be expected to select and organize subject matter. This is work for the educational architect, not for the novice. The teacher lacks the necessary geographical knowledge, the time, and frequently the energy to do this work, and even given these, she would usually find that the subject matter for a selection and organization was not available in her school. The 1921-22 "Report of the High School Visitor of the University of Illinois" shows that of 84 schools enrolling from 200 to 499 pupils, the median number of science books available in the high school library was 98. When you consider that these books include, in addition to geography, all available material in biology, physics, chemistry, agriculture, and household arts, and consider the usual ranking placed upon these subjects as compared with geography, you get some notion of how meagre must be the material pertaining to geography. It is reasonable to expect that the teacher's subject matter, and to some extent her method, are going to be largely determined by her text book.

Perhaps you are beginning to wonder if anything is to be demanded of this most essential element of our educational system, the teacher. Even with conditions as discouraging as indicated, there are still some few things which we may reasonably expect. Foremost of these, I should say, would be that we may reasonably expect the teacher to present some evidence of having some preparation in subject matter other than that obtained in elementary and secondary schools. Just at present in this state, a college or university graduate secures a high school certificate without examination. This certificate entitles the person receiving it to teach in the high school

without discrimination as to subjects, which means that if the teacher can secure a place as a geography teacher, she may teach the subject regardless of the fact that she may have had no training in it since leaving the elementary school. One would like to feel that the good sense of the teacher, the supervisor, and the school board, would make such a condition impossible; but a somewhat intimate knowledge of conditions in some schools of the state does not tend to assure one that such is the case.

Much controversy has existed as to whether geography was a physical or a social science. Perhaps the answer to this controversy would be that geography has its basis in physical science and its applications in social science. It would seem reasonable, then, to ask that the teacher have sufficient training in these two fields to enable her to intelligently interpret geographical facts. Since she will, of necessity, be required to teach other subjects, it seems reasonable to ask that she be prepared to handle classes in one or both of these allied fields. In addition to her textbook, the teacher will always have available one other source of valuable subject matter, namely the "out-of-doors" surrounding her school It seems reasonable to expect her to be able to apply her geographical knowledge to the explanation of such phenomena of the material world as she may find in her immediate locality. And finally, she may reasonably be expected to be familiar with the types of teaching that apply to her field. The scientific method, journey geography, the problem method, the project, the socialized recitation, and the organized field trip should be more than meaningless phrases to the teacher of geography. Not a great deal to expect, perhaps, but about all that may reasonably be expected under existing conditions.

THE PROBLEM METHOD OF TEACHING,

By Elmer Grant Campbell,
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The problem method of teaching, properly adminstered, comprises the leading of the student by the instructor, to a purposeful selection or acceptance of problems, broad or narrow in scope, the solution of which will challenge his ability and skill, call into operation previous knowledge and lead to the discoveries of principles and applications hitherto unknown to him.

A problem must be of such quality that each step in its solution will sustain, in the mind of the student, a feeling of

reward and a conviction that the thing will function in his life. For example:

John Dover lives on his farm one mile north of the University. Here is an unspecified weed. Give Mr. Dover full and expert advice as to its control or eradicaton.

The classroom periods in this method should be given largely to deductive discussions; and the materials thus presented. should be projected into the laboratory or field as problems.

This scheme is not presented here as a fixed thing in the art of teaching, but rather as a suggestion that students may be led to accept, in the classroom, problems narrow in immediate scope but sufficienty challenging in nature to inspire the spirit of originality in the laboratory.

To illustrate this scheme, one topic as treated in freshman botany is partially set forth in outline as follows:

A Lesson on Fruits (No Prerequisite Lesson Is Required).

The word "fruit" is written on the board, and the following leading questions are asked (the ideal answers to which the discussion led are placed in parenthesis):

1. What is the common idea expressed in the word fruit? (Edibleness—a horticultural meaning.)
2. Is there a more inclusive idea for the word? (Both edible and non-edible—a botanical meaning.)
3. Write a list of common horticultural fruits. (Apple, peach, pear, grape, currant, cherry, plum, and quince.)
4. Write a list of botanical fruits including both edible and non-edible. (Apple, cocklebur, strawberry, hickory-nut, peach, bean-pod, stick-tight, pear, jimson-weed pod, Spanish needle, ground cherry, melon.)
5. Can you, with this list before you, divide it into two classes on other bases than edibility? (Dry and fleshy.)
6. Write all the dry fruits in this list in one column and all the fleshy fruits in a separate column.

Apple	Cocklebur
Peach	Spanish needle
Grape	Stick-tight
Currant	Hickory-nut
Melon	Jimson-weed pod.

7. Name any one of the fleshy fruits in your list.

Apple may be named by some member of the class. If so the instructor states that the type name for fruits like the apple is Pome. This word is written on the board and the word apple indented under it, thus:

POME
Apple

The student writes it thus in his notebook.

8. If an apple is a POME, write under the word apple the names of all the fruits that you think are POMES. (Pear, quince, redhaw, etc.)
9. Name another fleshy fruit from your list.

This time peach may be suggested. If so, the class is informed that the type name for such fruits as the peach is DRUPE. The word DRUPE is written on the board and the word peach indented under it. The students write it thus in their notebooks.

DRUPE

Peach

10. If a peach is a DRUPE, write under the word peach all the DRUPES you know. (Plum, cherry, apricot, olive, etc.)

This exercise should be continued until all the most common types of fleshy and dry fruits are involved. Thus in the laboratory the student doubtless will gladly accept the challenge as set forth in the following problem: Here are ten unknown fruits, write a working definition of each class and type represented.

All conclusions reached by the student should be pointed out and explained orally to the instructor, the student being graded for the day's work upon his mental attitude and application and not upon his notebook. Copying under this method is unprofitable and is easily prohibited without a laboratory policeman.

POSSIBILITIES AND DIFFICULTIES IN THE PROBLEM METHOD.

In the problem method, the teacher's success depends upon his own humanity, optimism and enthusiasm. He must be sympathetic, he must be expectant and joyful with the student as new discoveries are being made. The teacher leads, but for the most part he seems to be following. The student follows, but from all appearances he is leading. He is jovially finding what in other methods are told in lectures or read in the textbooks.

In the Problem Method there is a reciprocal relation of good feeling between the leader and the learner. Thus school is not a policing system It is rather a happy, orderly exploring party, in which learning becomes the joy of living. Each step elevates, and if the student goes up his going is a gladsome, purposeful response to a call. The call is a congenial challange to his skill and ability. The call is a luring thing, drawing his soul into the mysteries of the unknown.

Ordinarily there is, in the student's mind, a tremendous concern for grade, or for "getting by." This attitude is correctable, but too often educational institutions foster it in such a manner as to almost quench the spirit of learning.

Perhaps no one feels that it is feasible to abolish our present grading methods with one stroke. But if it is in order here

to express a hope, let it be said that when the University shall have completed its long journey of progress, a plan will be reached wherein a student may be content to wait for the sum total of his grades until the gala week of his senior year, or longer. The University will issue such a grade as an appraisal of four years' work, an appraisal not only of what the student has done, but also of what the University itself has done. Under this plan, commencement will not be a verdict day on which announcements are made to the world that certain individuals have been acquitted of ignorance in various classrooms and laboratories. Commencement would be a day prophetic of new possibilities in the laboratory of the wide world. A day not significant of a finished accumulation of facts on the basis of which the student is celebrated and presented to the world as a toy bank stuffed with small coins, but a day spent as a moment's pausing and refreshing on the endless and luring path of mental development.

There is a widespread University custom of placing the classroom work in the hands of a superior and delegating the laboratory to other hands. Here is a notable fallacy in our modern educational dignity.

In the problem method, classroom and laboratory become one. There are no chief seats in the administration of courses. The man of high rank is called to prove the right of his dignity by following his own words and theories from the classroom into the realm of laboratory realities.

It requires power and patience to search out the real soul experiences of a student in the classroom, but it requires greater skill to rightly and safely guide an inquirer from the pinnacle of his known into the mysteries of the unseen, and no instructor should be called upon to enter this delicate process at the middle point and perform the miracle of connecting the known to the unknown, when the known is unknown to him. The instructor who goes directly from the classroom to the laboratory with his students, goes with numerous vital advantages that should never under any circumstances be deliberately surrendered.

It is fallacious and absurd to suppose that the laboratory and classroom of any course should exist incoherently. The classroom work should consist of mass conferences in which problems are raised and somehow tied into the past experiences and observations of the students. The laboratory should afford immediate and consecutive means of going originally into these

problems. As soon as the student is made to feel that a problem has a definite relation to his past experience, he is ready and eager to work forward, and much is lost if he is not allowed to do so at once. For this reason there seems to be no wisdom in the schedule that splits a four-hour course into two one-hour lecture periods plus one detached two-hour laboratory period, for often under this plan the work is scattered rather hopelessly from one end of the week to the other. If there is to be a four-hour course, it should be scheduled into not more than two two-hour periods per week, so as to enable the instructor to make a more perfect blend of his classroom and laboratory.

There is prevalent a notable misconception as to the purpose of laboratory work. Too often it is thought of as a performance, the details of which are ends in themselves. For example, recently a botany instructor was entering his laboratory having in his hand a bunch of dandelions. He was halted by a professor in a kindred department who remarked, "Are you not aware, sir, that all your students already know the names of those things? They can draw one without looking at it. They will make a hundred today." Thus he expressed a pitiful conception, that names and facts and drawings and grades constitute the sum total of laboratory values. That day the student discovered twenty botanical facts in his study of the common dandelion. These facts could have been obtained from a textbook, given in lecture, or over suggestive laboratory directions, but instead the student was led to accept a challenge and thereby he experienced the joys of mental motion. His problems were simply stated, and he reached his conclusions without a manual of details of "how to proceed." He was made to think of facts, records and grades if he thought of them at all, as secondary traveling necessities for his mental journey. After a while he may discover the whole truth, that if the baggage is to furnish all the joys and all the values of the trip, then to go is equivalent to not going. In conclusion, let it be said that in the problem method of teaching, the instructor must deal in constructive issues; he must be given little to negative character rating. He must learn that when a student has been led to set his head and hands enthusiastically to the solution of a worthy problem, broad or narrow in scope, much has been done toward the making of a strong and useful character. And this is the noble end of all mental movement.

A DETAILED PLAN FOR PRESENTING THE TOPIC "ENERGY" TO A PHYSIC CLASS, WITH MODIFICATIONS FOR ITS USE IN A GENERAL SCIENCE CLASS.

By O. E. Underhill,
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During my first year of teaching, I attempted to get helps and suggestions as to teaching methods from several books and publications. I found, therein, a great many general statements as to teaching methods, but none given in detail. Some books, on teaching methods, stated that no detailed plans could be given as no two teachers would care to present a topic exactly alike; that each teacher should develop his own methods to suit special needs; and other such statements of like character. This is all very true. I know it would have helped me, however, if during my first year of teaching I could have found some detailed lesson plans. Not that I would have followed any given plan to the letter, but it would have helped me in formulating plans of my own. There were, perhaps, two things that helped me most during my first year of teaching. The first was a lecture given by Mr. Lundt at the teachers' convention held in Portland, Maine. He told in detail how he presented one or two topics to his general science class, and how his class responded to his methods. His talk gave me some ideas about making a class interesting. I attempted to put those ideas into practice, with the result that I can take this time as a turning point in the attitude of my general science class that year; my first year, teaching high school students. From that time on, my class was much more interesting, and the following year, after I had had time to more thoughtfully follow out these methods, the marked improvement in the attitude of my class was very noticeable. The second aid was the detailed outline for teaching the topic "heat" given in "Science Teaching," by Twiss.

Because of the help I received from one or two such detailed plans, I am presenting in detail a method for teaching a topic in physics, with the hope that it might be found helpful by some one who is teaching science for the first time, and has had no teaching experience.

The object of this lesson will be to bring to the student the words "energy," "potential energy," "kinetic energy"; to develop the formulas for these two kinds of energy; and to furnish an opening for the topic "conservation of energy."

I am assuming that, as the topic energy is about to be taken up, the previous lessons will have dealt with work and power,

having established the fundamental principles which might be expressed by the mathematical fomulas: W = Fd, and P = W/T.

I am assuming, also, that the topic is being taken up prior to any textbook work on the subject by the pupil. Personally, I prefer, as a rule, to discuss a new subject with the pupils before assigning textbook work on the subject. My general plan has been to discuss a topic the latter part of a period. At the end of the period I would assign textbook reading over what we had taken up in class, and the first of the next recitation (usually the second day, a laboratory period coming in between) have a more or less formal recitation on the subject. Sometimes the class discussion would be drawn out by outside material to two or three periods, but I try to follow the general order of a class discussion, followed by a formal recitation (quizes, etc.), with the textbook assignment coming in between.

I am, then, ready to begin the class discussion, the class having a knowledge of work and power, but no textbook knowledge of energy. I should begin by stating that we were going to discuss the topic, "energy," and print the word in capitals at the top of the blackboard. I would then ask the class what the word "energy" meant to them; ask them for examples of things with which they connected the word "energy," and have them give reasons why they associated the word "energy" with the examples given. The examples first given would probably be automobiles, engines, electric cars, etc. By following out this line of questioning about things of which they know something, it could be brought out that the various things named were all connected in some way with motion. It is not likely that anyone will mention a body at rest as having energy unless they have done some reading on the subject. If someone does mention something as gunpowder, or a clock spring, the attention of the class can be turned to the motion of the bullet, or the wheels of the clock until the teacher is ready to take up potential energy. After having given as many examples of manifestations of energy as possible, and shown in each case their relation with motion, I would write the word "motion" on the blackboard.

The next step is to make the class associate energy with bodies at rest. I would pick up a large weight (about two kilograms) and ask the class whether there is any energy there. Someone will state that there is, and I would ask for a show of hands as to how many believe there is energy in the weight. Most of the

class will raise their hands, either instinctively associating energy with weight, or because of the way the question is worded. I would then ask them to give reasons why they believe this. This will probably result in some confusion. Some will associate energy with weight but will find it hard to express their idea clearly. About this time I would rather unexpectedly drop the weight, which will at least serve to awaken anyone who may have fallen asleep. I have found the effect to be electric. Several hands are immediately raised. The idea that the weight is capable of making a noise and therefore has energy, seems to come to them at once. I say that if anyone does not believe that the weight has energy I would be glad to have him come forward and allow me to drop it on his toe. From this idea it is easy to bring out by questions the fact that the weight can strike a blow i. e., exert force. I would try to get the expression from the class (but if I could not readily, I would state it to them) that the weight is *capable* of exerting *force*. I would then link this up with the thought of motion or distance and thus get at the definition, "energy is the capacity for doing work." (Millikan and Gale, "A First Course in Physics.")

The next step is to try to get from the class the phrase "energy of position." I would ask the class if the weight as it lies on the table has energy, at the same time pushing it slowly off the edge. The answer, of course, comes in the affirmative. I would then ask whether the weight might have different amounts of energy (i. e., different capacities for doing work) at different times. If the idea does not come from the class, I would ask if the weight might hit the foot so that it would hurt more at one time than at another, and this line of thought would easily lead to the suggestions that dropping it from a higher place, throwing the object, or increasing its weight would all result in a harder blow. Thus the ideas of weight, position, and velocity as influencing energy would be suggested. From this, the word "position" might be gotten from the class, or given to them, and the phrase "energy of position" applied to the weight that is supported by the table. Examples of energy such as the pile driver, or a coiled spring may then be drawn from the class. The word "position" may then be written on the blackboard, and the words "potential" and "kinetic" introduced, linking the word "potential" with "position," and "kinetic" with "motion," on the board. I would then have definitions and origins of the words looked up and read to the class by some member, emphasizing the points

"pertaining to motion," and "by virtue of position" as found in the dictionary definitions. The students will already be familiar with the word "kinetic" as the molecular theory will have been taken up in connection with the previous study of gases.

I would then suggest that we ought to have some means of measuring this energy or capacity for doing work. This phrase may give rise to the thought that work is measured in foot-pounds or gram-centimeters, and therefore energy should be. In this the relations between force and weight, distance and height, and potential energy and work, may be brought out, and the expression P. E. = Mh be derived from W = Fh. This may also be arrived at by going back to the thought of the weight falling on one's toes. It is easy to bring out by discussion that the heavier the weight, the more it will hurt, and the greater the height from which it falls, the more it will hurt. Therefore, the amount of energy which it contains may be measured in terms of height and weight. I would then give the formula P. E. = Mh and put it on the board grouped "potential" and "position."

The next point to be developed is the relation of knetic to potential energy and the change from one to the other. This can be brought about by calling attention to the fact that when the weight strikes the floor, it is in motion, and the changes of energy from potential to kinetic in a pile driver, watch spring, pendulum etc., may be discussed.

I would then ask what makes the weight fall, and get for an answer "gravity." From this I would develop the relation of gravity to the change in energy, and arrive at the formulas expressing potential energy in terms of ergs, and of potential energy in terms of velocity. (N. B. Upon submitting this paper to an experienced teacher for criticism it was suggested that it would be better not to deal with ergs to a high school class.)

This would leave on the board as a summary the brief outline:

ENERGY.

position	motion
potential	kinetic
P. E. = Mh gm. cm.	K. E. = 1/2 Mv^2
= Mgh ergs	

This would lead to energy changes, chemical, electrical, heat, light, their transformations; and the law of conservation of energy, which, of course, would make other complete topics.

I would, at the conclusion of the above, which might take a

part of one period, or all of two periods, depending on how readily the class responded, assign textbook work covering this, with perhaps one or two problems to be passed in. The next recitation I might have a ten or fifteen minute quiz with a problem or two, or perhaps a formal recitation. Then we would be ready to start on another discussion.

This one topic, of course, merely opens up the field of energy. Under heat, sound, light, electricity, etc., one would continually return to the principles of conservation and transformations of energy. Caldwell says in his report, "The Reorganization of Science in Secondary Schools," "—and this principle (conservation of energy) may be taken as the great unifying generalization by means of which the phenomena in all departments of physics are to be linked together."

PRESENTATION OF THE TOPIC "ENERGY" TO A GENERAL SCIENCE CLASS.

The preceding paper is an attempt to place certain ideas before the pupil by causing him to talk about and apply what he already knows. This general principle is of great importance in successfully teaching general science to high school freshmen. If they can be drawn out into talking about things of which they have some knowledge, they will be interested. The following paper is a modification of the precedng paper to adapt its plan for use in a general science class where the pupils are younger.

In my general science class I usually take up a new topic with the class, before assigning textbook work, in the same way as spoken of in the preceding paper. The class is usually in a more or less expectant attitude, wondering what is coming next. This interest is especially marked if I am able to have a few pieces of demonstration apparatus on my lecture table. I try to open the lesson with a question that will hold their interest and perhaps arouse a little curiosity as to what is coming. I think it best with upper classmen (as those taking physics) to state the topic to be discussed, as I did in the previous paper on presenting this topic to a physics class. In general science, however, the students are younger and I believe it holds their attention and interest to keep them guessing as to what is coming until one is ready to bring home some particular point.

The points which I wish to bring out in this lesson are the meanings of the words "energy," "kinetic," and "potential"; and the broad principle of "conservation of energy."

I might open the lesson with the question, "How many of you have a watch?" A few hands will probably be raised eagerly, as high school freshmen do not all carry watches, and the boy with his watch, or the girl with her wrist-watch is rather proud of it, and eager to let the rest of the class know of their possession. Choosing someone who has signified ownership of a watch I might ask such questions as: "What makes it go?" "Does it ever stop?" "What makes it stop?" "Can you make it go again?" "How?" "Why does it not go when it is run down?" etc. By such questions I can soon bring out that there is something different in a spring when it is wound up from when it is run down. Something has been put into the spring in the winding. I would try to get the word "energy" from the class, but if I could not readily, I would give it to them. I then would try to get at what energy meant to them, and connect it with motion by asking them about the various mechanical things they had knowledge of, much as described in the previous paper. In the same way I would bring out energy of position using, perhaps, a book instead of the weight. I think it might appeal to younger pupils more to discover that a book has energy, rather than a weight, which might carry along with it psychological associations of machinery or laboratory experiments, or something of the sort

I would try to get at the words "potential" and "kinetic" in much the same way as previously described, striving to make the pupils familiar with the meanings of the words, but, of course, omitting all mathematical work, I am in doubt whether it be advisable to link up the force of gravity with potential energy in a general science course.

From this point I would go on to energy changes and conservation of energy, perhaps making more of this than in the previously outlined work for the physics course. I would pay particular attention to the tracing of the manifestations of energy, known to the pupils, to their sources. Take for example the kinetic energy of a moving street car. This energy comes from the electrical energy supplied to the car by the power house. If the dynamos in the power house are run by steam I would mention the heat energy locked up in the coal; its storage there by changing the sun's energy through chemical action (i. e. photosynthesis). If the electricity were generated by water power I would call attention to the formation of the streams through the evaporation of water from the earth by the sun and its return

to the earth in the form of rain, etc. As the general science course would not have the opportunity to trace energy changes and bring out the law of conservation of energy through the following work as would be done in physics, I think it should be treated more thoroughly at this point, than if it were a physics course.

The important thing in the use of this method is to begin by having the pupils tell you what they know already. If they can be asked questions about every-day things of which they know something, they will be interested, and eager to tell about it. Again, it is a psychological fact that memory is aided by association of ideas. Thus, by making the pupil associate what you are trying to teach him, with something he knows already, the one idea will be recalled by the other. In this way knowledge, not merely a meaningless collection of memorized words, will be gained. Also, some opening should be left whereby the future topics may be linked with the topic under discussion.

The completed lesson plan should, then, do the following: first, start the pupil talking about every-day things which can later be associated with the points to be taught; second, associate with these things the new material you wish the pupil to remember; third, assign some outside work, over the subject, which will make him think over what has taken place in the recitation, and which will make him need to use this knowledge gained in recitation, to understand the textbook; fourth, review the pupil's grasp of the subject by an examination of some sort, either written or oral.

PLANTS STOP SWEATING TO SAVE SELVES IN DROUGHT.

That plants neither toil nor spin has long been known on high authority, but the Ecological Society of America learned from G. A. Pearson, director of the Fort Valley Forest Experiment Station, Flagstaff, Ariz., that in periods of water scarcity the trees native to the Southwest have the remarkable power of reducing the "sweat of their brow" to almost nothing.

"Plants transpire or give off moisture through the leaves in much the same manner as we perspire," he told his fellow scientists. "The rate of transpiration has an important bearing on the ability of plants to grow in a dry climate. If water escapes faster than it is replaced by the roots the plant wilts, and, if this unfavorable balance continues long, death ensues."

In many sections of the country, and particularly in the Southwest, the forests restock with difficulty because young seedlings are often unable to withstand protracted periods of drought. At the Fort Valley Forest Experiment Station we have carefully studied the rate of transpiration of coniferous tree seedlings. All of the native species have shown a remarkable capacity for adjustment in time of famine. When the water supply in the soil nears exhaustion, the seedlings reduce transpiration to almost nothing, and they may continue to live in this condition for several months.—*[Science Service.*

TESTS AND MEASUREMENTS IN HIGH SCHOOL SCIENCE

By G. M. Ruch,

University of Iowa.

The idea of measurement in high school subjects is decidedly in its infancy. The introduction of the newer methods of grading, classifying, and measuring in the secondary schools has lagged far behind the progress of these methods in elementary education. The sciences and mathematics are by no means more backward than the other high school subjects, with one or two possible exceptions, in the substitution of reliable and objective measures for the less dependable essay examinations and subjective judgments. In fact, the quantity of science and mathematical tests which have appeared to date is more than sufficient as is shown by the twenty-five tests and scales listed and described below.

On the other hand, it must be admitted that less than a half dozen of these so-called tests are tests in more than name only. Few have been carefully validated against a good outside criterion. Adequate norms are available only in isolated cases. Probably the more technical issue of reliability (in the sense of self-correlation) has not been raised in more than four or five cases in the following list. The most hopeful sign is that of the widespread interest in high school testing which is rapidly arising. For this reason, and because of the many inquiries which come to the writer, it is thought worth while to summarize the present state of the science of measurement in two general fields of high school instruction. This the writer hopes to do for the sciences in the present article and follow with a similar treatment of the mathematical subjects in a second paper.

The data reported here have been gathered from a variety of sources. The existing bibliographies and trade catalogs have been consulted as well as the current literature in the journals. The writer has supplemented parts of the discussion from his personal experience and study of some of the tests. He has also sent out to the authors of the several tests information sheets asking for all of the existing facts about the validity, reliability, norms, etc., of the tests and scales.

Although it has not been deemed necessary to enter into the technical considerations of educational measurement, a word of explanation of some terms used may not be out of place. By the term *validity* is meant the degree to which a test measures what it *purports* to measure. By reliability is meant *how accurately*

the test measures what it really does measure, not necessarily what it purports to measure. A valid test must have high reliability although the converse does not hold. A test may be very reliable (have high precision) and yet not have value in measuring what it is claimed to measure. The most reliable conceivable physics test might be totally invalid as a measure of biology, but if it is really a valid physics test it must not only measure physics and physics alone, but it must also measure physics *well*. Validation is assured by scientific selection of test items and careful tryouts against a criterion. Reliability is usually estimated by self-correlation, i. e., by correlation of one form of the test against a second form or some similar procedure.

The tests are discussed in topical groups, the arrangement being alphabetical within the group.

A. *Biology.*

1. Grier, N. M.: Range of Information Test in Biology. Part I. Physiology, Part II. Zoology, Part III. Botany. Not published separately from article cited. Reference: Jour. Educ. Psych., 1918, 9, 210-216; 1918, 9, 388-393; and 1919, 10, 509-516.

Each test consists of 100 terms related to each of the three sciences which were validated by analysis of textbooks, spellers, school readers, and general magazine articles. The pupil marks each item D, E, F, or N to denote the degree of familiarity of the term. In order to provide a check on the accuracy of the ratings the pupil must write out full definitions of the first five words as well.

The reliability has not been determined. The scoring is largely subjective and open to the further objection that it is done by the pupils. The norms are stated in terms of the percentages of correct items.

The norms are given in the three articles cited. Norms are provided for first half and second half of the year separately. The test has not been adequately standardized.

2. Ruch, G. M. and Cossmann, L. H.: Biology Test. Published privately as yet by the authors. Can be had in mimeographed form by addressing G. M. Ruch, University of Iowa, Iowa City, Iowa. No printed descriptions of the test are yet available.

The test is standardized tentatively in two forms known as Form A and Form B. The test items were selected and validated by the collection of several hundred items from final examination papers from a dozen or more of the leading high schools in each state. Those frequently appearing were classified and rated by 77 expert judges for desirability and only those items rated by 50% or more of the judges as being entirely satisfactory were retained. The test consists of five parts, as follows: Test 1, 40 items of general information; Test 2, 18 "best answer" questions; Test 3, identification of 15 plant and animal structures in a plate of 4 diagrams; Test 4, test on Mendelian inheritance ratios; Test 5, completion exercise of 37 items. All of the items were validated on several hundred pupils by the method of computing the per cents passing and failing. The time needed to administer one form is about 45 minutes. The scoring is completely objective and can be done by the use of stencils. The norms are based upon about 400 tenth grade pupils.

The reliability of the test based upon correlations of the scores for Form A with those for Form B has been found to range between .80 and .90.

B. *Chemistry.*

1. Bell, J. C. Chemistry Test. Reference: Jour. Educ. Psych., 1918, 9, 199-209. Address of author: Brooklyn Training School for Teachers, Brooklyn, N. Y. Not sold separately from article cited.

Further discussions of the use of this test can be found in the following:

Bell, J. C.: Study of the Attainments of High School Pupils in First Year Chemistry, Sch. Sci. and Math., 1918, 18, 425-432.

Briggs, T. H.: Results from the Bell Chemistry Test, Jour. Educ. Psych., 1920, 11, 224-228.

Gerry, H. L.: Further Data on the Bell Chemistry Test, Jour. Educ. Psych., 1920, 11, 398-401.

The test consists of twenty-five questions concerning general first year chemistry. The norms are expressed in terms of the percentages of pupils answering each question correctly.

The scoring is subjective and, as far as the writer knows, the reliability has not been determined.

2. Finger Chemistry Test. Not yet completed. Address of author: C. P. Finger, University High School, Oakland, California. These tests will be the result of a very careful study of good teaching practice in chemistry and the standardization will doubtless be accurate.

The test is in five parts, as follows: I. Classification of reactions (as combination, decomposition, displacement, or double decomposition); II. 20 true-false questions on fundamental chemical processes; III. matching test of 20 laws and principles with the same number of chemical phenomena; IV. matching test of 44 substances with their chemical names; V. 17 problems, the right solutions to be checked in a list of 4 possible solutions.

3. Glenn Chemistry Tests. Not yet completed. Address of author: E. R. Glenn Lincoln School, Teachers College, N. Y. City. This test is being standardized at present. The author's preliminary work on science tests is discussed in part in the following article: Glenn, E. R.: Conventional Examinations in Chemistry and Physics versus the New Type of Test, Sch. Sci. and Math., 1921, 666-670 and 746-756.

The test is in 4 parts, as follows: I. matching test of a biographical nature; II. formulas and symbols; III. range of information in chemistry; IV. problems.

4. Jones Union Chemistry Test. Address of author: Jones, F. T., 10109 Wilbur Avenue, Cleveland, Ohio. Reference: School Review, 1918, 26, 341-348. Topics covered include: writing symbols, formulas, equations, valences, etc.

No norms are available and the reliability has not been determined. Results obtained in the author's classes are given in the above article.

5. Powers Chemistry Tests. Address of author: S. R. Powers, Department of Education, University of Minnesota, Minneapolis, Minnesota. The test is printed at present in experimental form only by the World Book Company, Yonkers, N. Y. The preliminary test consists of 60 items of the nature of a range of information test about chemistry. Additional types of tests are also being standardized. These will include items on formulas, valences, equations, and classifications of elements, compounds, and mixtures.

This test is being scientifically validated and will, when completed, prove a valuable measuring instrument. For a preliminary account of the experimentation see the following: Powers, S. R.: The Achievements of High School and College Freshmen Students in Chemistry, Sch. Sci. and Math., 1921, 21, 666-670 and 746-756.

The reliability of the test is being studied and from advance reports received by the writer appears to be satisfactorily high.

6. Rivett Time Limit Tests in Chemistry. Address of author: B. J. Rivett, 6300 Grand River Avenue, Detroit, Michigan. References: Results with Standard Chemistry Tests, Sch. Sci. and Math., 1921, 21, 72-722; and, Testing Results in Chemistry, ibid., 1919, 19, 742-745.

Not standardized or validated. Reliability not determined. Is primarily a teaching device rather than a measuring instrument.

7. Webb Test of Previous Information in Chemistry. Address of author:

H. A. Webb, George Peabody College for Teachers, Nashville, Tennessee. Reference: Webb, H. A.: A Preliminary Test in Chemistry, Jour. Educ. Psych., 1919, 10, 36-43.

Consists of a list of 50 words to be classified by marking E, M, and C, respectively, for elements, mixtures, and compounds. Intended for use with students beginning chemistry in order to determine their previous knowledge of the subject.

Not validated or standardized.

8. Webb Test of Laboratory Resourcefulness. Address of author given above. Reference: Webb, H. A.: Testing Laboratory Resourcefulness, Sch. Sci. and Math., 1922, 22, 259-266.

A series of thirteen laboratory tests in the setting up and manipulation of apparatus.

Norms are given in terms of median times to set up each set of apparatus. The test is not fully standardized. Boys appear to excell girls rather markedly.

C. *General.*

1. (Caldwell) Gary Science Tests. Address of author: O. W. Caldwell, Lincoln School, Teachers College, N. Y. City.

These tests were used in the survey of the Gary public schools. Reference: Caldwell, O. W.: The Gary Public Schools: Science Teaching, 1919, General Education Board, N. Y.

Nine tests involving knowledge of leaves, birds, and insects. Observations and experiments are included. The tests were given in grades 7 and 8 and in grade 12 of the high school.

These tests have not been standardized.

2. Downing Range of Information Test in Science (Revised). Address of author: E. R. Downing, University of Chicago, Chicago, Illinois.

This test consists of 50 terms drawn from the various sciences. The pupil places an E, F, or N before each word to indicate the degree of familiarity with the term. The preliminary test is described in the following reference: Downing, E. R.: What Standard Test in Science Should Do, Sch. Sci. and Math., 1919, 19, 651-654. For an account of the revision, see: Downing, E. R.: Range of Information Test in Science, ibid., 1920, 20, 77-83.

These tests have not been fully standardized. The scoring is subjective and unreliable. They can be secured from the author at a cost of forty cents per hundred. The reliability has not been determined.

3. Herring Tests of Scientific Thinking. Reference: Herring, J. P.: Measurement of Some Abilities in Scientific Thinking, Jour. Educ. Psych., 1918, 9, 555-558, and, 1919, 10, 417-433. Not available elsewhere.

A series of 93 exercises to test powers of selection, values, definition, comparison, classification, etc.

Grade norms for grades 9 to 12 are provided. The norms are based upon about 450 cases.

D. *General Science.*

1. Caldwell-Glen General Science Tests. Not standardized or published to date. Address of authors: O. W. Caldwell and E. R. Glenn, Lincoln School, Teachers College, N. Y. City.

This test is based upon the course of study in general science in the Lincoln school and exists as yet only in mimeographed form. The scoring is not completely objective. It consists of 50 questions to be answered by a single word or phrase.

No norms have been established. The reliability has not been determined.

2. Dvorak General Science Test. Address of author: August Dvorak, University of Minnesota, Minneapolis, Minnesota.

This test is entirely of the information type. It consists of 300 items gathered together from various sources together with much original material. The test was devised for purposes of a survey of general science abilities

in the schools of Minnesota. To date about 15,000 pupils have been tested in grades 8 to 12. These results will be used in the production of several shorter scales which will be standardized.

3. Maxwell First Year Science Tests. Address of author: P. A. Maxwell, Avalon, Pennsylvania.

This test is provided in two forms designated as Series A and Series B. Each consists of 30 information items and 8 reasoning questions. Norms on 665 pupils are provided. The items are weighted according to the percentages passing and failing. The reasoning tests are completely objective in their scoring. The information tests are almost entirely objective.

As far as the writer knows, the validation of these tests has not been described in print. The reliability has not been determined. The two forms are approximately equal in difficulty.

4. Ruch Range of Information Test in General Science. Not available except as printed in the reference given. Address of author: G. M. Ruch, University of Iowa, Iowa City, Iowa. References: Ruch, G. M.: A Range of Information Test in General Science, Gen. Sci. Quart., 1919, 4, 257-262, and ibid., 1920, 5, 15-19.

Incompletely standardized. Scoring subjective and not very reliable. Items obtained by analysis of 25 textbooks in general science. Three roughly equal forms of 50 items each are provided.

This test has been superseded by the one which is described in the following paragraph.

5. Ruch-Popenoe General Science Test. Address of authors: G. M. Ruch, University of Iowa, Iowa City, Iowa, and H. F. Popenoe, Preston School of Industry, Waterman, California. Publisher: World Book Company, Yonkers, N. Y.

This test is available in two forms designated as Form A and Form B. Each consists of two parts: Part I. 50 items of general information about elementary science; Part II. 20 drawings of structures and apparatus together with 80 completion blanks to be filled in by the pupil. The test requires 40 minutes working time.

The items were selected by textbook analysis and the combined judgments of competent teachers. The relative difficulties of the items were found by the percentages of pupils passing and failing each. Several hundred pupils representing about a dozen classes in five different states were involved in the preliminary try-outs of the materials.

The reliability coefficients for four high school classes were .80, .81, .85, and .87, respectively. The probable error of a score is about 3 scale points.

Fairly reliable percentile norms based upon 363 selected cases are available. These can be had from the manual of directions furnished by the publishers.

This test replaces the older Range of Information Test and is practically completely objective. The scoring is easily done by means of stencils.

6. Toops General Science Test. Address of author: H. F. Toops, Institute of Research, Columbia University, New York City. Available only in mimeographed form. Not standardized. Based upon Caldwell and Eikenberry's text in general science. This test may later be standardized.

It consists of 50 questions which in most cases require but one word for an answer. The scoring is somewhat subjective but is easily done. No norms are available. The reliability has not been determined.

E. *Physics.*

1. Camp Physics Test. Known as the Iowa Physics Tests. Devised by H. L. Camp. Reference to account of standardization: Camp H. L.: Scales for the Measurement of the Results of Physics Teaching, Jour. Educ. Res., 1922, 5, 400-405.

Consists of three parts, Series A, mechanics, Series B, heat, and Series C, electricity and magnetism.

2. Chapman Test in Electricity, Magnetism, Sound and Light. Address of author: J. C. Chapman, Yale University, New Haven,

Conn. Reference: Chapman, J. C.: The Measurement of Physics Information, School Review, 1919, 27, 748-756.

Consists of 50 questions designed to measure information about physics. Not fully standardized. Decile norms based on 158 pupils in one school system are provided.

3. Glenn Physics Tests. Under construction. See Glenn Chemistry Tests for general description of the nature of these projected tests. The physics tests will be similar to the chemistry tests according to tentative information available at present.

4. Jones Union Physics Test. See also the Jones Chemistry test already described. The physics tests are similar in aim and scope. Reference: Jones, F. T.: Practice Exercises in Physics, School Review, 1918, 26, 341-348.

The test is a series of nine tests covering the general field of high school physics. The norms are given in terms of the percentages right of the tests attempted within the time limits provided.

The standardization of this test is incomplete. The author has not studied its reliability.

5. Starch Physics Test. Address of author: Dan Starch, Harvard University, Cambridge, Mass. Reference: Starch: Educational Measurements, 1916, Macmillan.

The test consists of 75 questions of the completion type, classified according to sub-topics as, mechanics, heat, light, sound, magnetism and electricity.

The materials were selected upon the basis of textbook analysis. 102 items treated by every one of the 5 texts studied were selected and incorporated into the mutilated text form. The texts were: Black and Davis, Carhart and Chute, Hoadley, Mann and Twiss, and Millikan and Gale.

The test is roughly standardized and has been used to a considerable extent.

The reliability of the test has not been reported as far as the writer can learn from the literature.

6. Thurstone Physics Test. One part of the series published under the name of the Thurstone Vocational Guidance Tests. Publisher: World Book Company, Yonkers, N. Y. Cost, $1.00 for a package of 25 tests. Address of author: L. L. Thurstone, Carnegie Institute of Technology, Pittsburgh, Penn.

This is undoubtedly the most carefully constructed and standardized physics test that has appeared to date. It is suitable for use with high school seniors or college freshmen. The scoring is rapid and objective.

This test was intended to predict probable success of students in engineering and use has shown its value for this purpose.

The reliability is known to be very high.

Time required thirty minutes for the twenty-five problems provided.

The other five tests of this series include: Arithmetic, Algebra, Geometry, and Technical Information.

The writer cannot resist the temptation in this closing paragraph to voice the argument for better constructed tests in high school science. In fact, as he wrote these pages he was constantly and unpleasantly forced to make repeated use of such comments as: "This test has not been completely standardized," "Reliable norms are not available," "The reliability of this test has not been determined," etc., etc. We must have measuring scales whose margins of error are accurately known. Next to knowing that the content of a test is pertinent, fair, and valid, the next important issue to be met is its reliability. How

well will a second form of the same test correlate with the one given? This is but another way of asking how nearly can the obtained score be taken at its face value. If the individual score is likely to be in error by a number of scale points which is a considerable fraction of the total variability (standard deviation) of the whole distribution of the scores, then, it follows that too great confidence cannot be placed in the score of any given individual. For the peculiar purposes of measurement in separate high school subjects, questions of validity and reliability far out weigh in importance the questions of norms. Tests which will accurately space the pupils of a class along a reliable scale of values will answer almost every purpose of educational testing. Measurement at best is merely assigning values in terms of arbitrary units. Even in the exact sciences like physics and chemistry, all that we purport to do is to assign values which are equal one to another even if the unit selected has no ultimate significance. If we can place students reliably along an artificial scale of values in their educational abilities, we have solved most of the fundamental problems of educational measurement.

THE SCIENTIFIC METHOD OF REASONING vs. THE MEDIEVAL DEDUCTIVE METHOD.

By Lyman C. Wooster

The Kansas State Teachers College of Emporia

In the scientific method of reasoning the student must proceed from the particular to the general and then from the general to the particular. The medieval method of reasoning accepts the general on authority and then proceeds to the particular. Thus the scientific method is inductive—deductive, the medieval is purely deductive.

The modern biological, physical, social and household sciences are naturally inductive-deductive; mathematics, the classics and much history teaching are based on rules, definitions and philosophic statements and are therefore deductive in their mode of procedure.

This paper is prepared to show in outline the difference between these two methods of reasoning and to contrast the educational values of the two methods.

1. In reasoning, the student may obtain his facts or truths

(a). By observation in natural situations. This work may become exceedingly interesting as is shown when the collecting instinct is fully aroused in doing pioneer work collecting plants,

insects, fossils, remains of ancient civilizations and in making explorations of the earth, sea and heavens.

(b). By experiments in laboratories. The results of these studies in chemistry, physics, medicine, sanitation, food preparation, biology and agriculture are of the highest value.

(c). On the authority of some one else. By far the greater proportion of the facts we use in scientific work are obtained from reference books, monographs and school text books. No one can possibly get them for himself at first hand. Life is too short.

2. Comparison and classification.

(a). By self. Isolated facts are of little use or value. Whatever the source of the facts, each student may profitably spend much time in sorting and arranging them in classes, orders, genera and species. Should he become expert in this work he will enjoy it exceedingly.

(b). On authority. As all students can not spare the time, or have the requisite knowledge or ability to become proficient in classification-making, the classifications prepared by experts are of high value.

(c). By use of natural and artificial keys. Locating specimens in their proper species by the use of keys requires much skill on the part of pupils, but this phase of work in botany, zoology and other subjects in natural history has certainly been carried to a profitless extreme in past years and has nearly driven these subjects from high schools.

3. Theories or generalizations may be obtained

(a). By induction of facts obtained in one or all of the three ways mentioned above. The collector of facts is always best fitted to form theories or generalizations from them. Scientific reports made up chiefly of facts collect dust in many a library and office.

(b). On authority of some one else. In this case the generalization becomes a major premise, the basis of reasoning in the Dark Ages. This is as good as the authority quoted and no better.

4. The student next hunts for

(a). Inferences that follow legitimately from the generalization and which throw light on new and related fields of study.

(b). Verifications. These give support to the theory or generalization and strengthen the belief of the student in its truth.

(c). Applications or minor premises. These present no new truth for the minor premise is contained in the major premise.

5. Conclusion reached

(a). By deduction, the universal method in all forms of reasoning.

(b). On the authority of some one else, making the conclusion of the medievalist to the syllogism. The ancient Greeks constructed many theories and generalizations inductively from observed facts. They did this so successfully that the medievalists concluded that there was nothing new for them to discover and so they stagnated thruout the Dark Ages.

The work of scientists during the past one hundred years has demonstrated, however, that the inductive-deductive method of reasoning is capable of placing man in possession of thousands of truths and conveniences not dreamed of by the Greeks.

This outline study of the scientific method of thinking as contrasted with the medieval method makes the use of purely deductive studies in school of doubtful educational value unless it can be shown that these subjects function materially in the after lives of high school and college boys and girls. They certainly do not give a discipline, according to brain specialists and psychologists, that can be used in the mastery of other and functional subjects and the *ego* is not materially modified by their use.

Brain specialists have discovered that the twelve hundred million nerve cells of the cerebrum, so far as they are functional, are highly specialized and that the division of labor is complete. Psychologists oppose formal discipline for their experiments show that training in one subject does not carry over into another and different subject unless the two subjects are covered by an ideal or they have a common element. In the latter case the transfer covers merely the common element, and not then unless the student knows it is common.

The writer is aware that he has run against traditions and unyielding prejudices in this paper, but he has merely voiced the belief of many educators. If they are wrong they should be corrected.

Reinforced concrete is to be used to prevent the collapse of the great tower of the Strasburg Cathedral designed in 1439.

PROBLEM DEPARTMENT.

CONDUCTED BY J. A. NYBERG.
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, Hyde Park High School, Chicago.

SOLUTION OF PROBLEM.

796. *Proposed by C. E. Githens, Wheeling, West Virginia.*

What other integral solutions of $d^2=s^2+bs$ exist besides:

$$d=6a \qquad b=5a \qquad s=4a?$$

Solution by F. A. Cadwell, St. Paul, Minnesota.

Let a and x be any integers, and y any integer not greater than x and exactly contained in x^2. Then

$$d=xa \qquad s=ya \qquad b=a(x^2-y^2)/y$$

Since x, a, and y are integers, xa and ya are integers; also x^2-y^2 is divisible by y because x^2 is, by our assumption. Therefore $a(x^2-y^2)/y$, or b, is an integer.

Since $d^2=x^2a^2$, $s^2=y^2a^2$, and $bs=x^2a^2-y^2a^2$, the above expressions for d, s and b satisfy $d^2=s^2+bs$. The following table gives some of the solutions which may be found by the above formula:

d	$2a$	$3a$	$4a$	$5a$	$6a$	$10a$
s	a	a	a	a	a	$4a$
b	$3a$	$8a$	$15a$	$24a$	$35a$	$21a$

Also solved by *E. B. Escott, Oak Park, Ill.; Michael Goldberg, Philadelphia, Pa.; Elmer Schuyler, Bay Ridge High School, Brooklyn, N. Y.*, and the *Proposer*.

797. *Proposed by Nelson L. Roray, Metuchen, New Jersey.*

Find the general expression for the number that 2, 3, 4, 5 and 6 will each divide with a remainder 1, but 7 will divide with a remainder 0.

Solution by M. Freed, Wilmington High School, Los Angeles, Cal.

Let N be the required number. By our conditions $N=60a+1$, where a is any positive integer. Since N is divisible by 7,

$N/7=(60a+1)/7=8a+(4a+1)/7$. Let $b=(4a+1)/7$. Then

$a=(7b-1)/4 = b+(3b-1)/4$. Let $c=(3b-1)/4$. Then

$b=(4c+1)/3 = c+(c+1)/3$. Let $d=(c+1)/3$. Then

$c=3d-1$.

Hence $b=c+d \quad =4d-1$

$a=b+c \quad =7d-2$

$N=60a+1=420d-119$ (or $420d+301$), wherein d is any positive integer.

Also solved by *C. E. Githens, Wheeling, West Virginia*, and *Michael Goldberg*. As problem 811, *M. Freed* proposes a generalization of this problem.

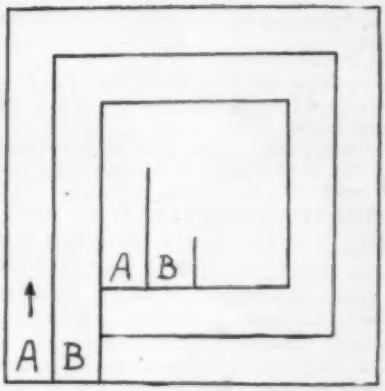
798. *Proposed by J. F. Howard, Brackenridge High School, San Antonio, Texas.*

What is the relation between the velocity of a man and the velocity of the end of his shadow, l being the height of the source of light and h being the height of the man?

Solution by Michael Goldberg, Philadelphia, Pa.

Let S = horizontal distance of end of the shadow from the source of light, and s = distance of man from the source. Then from similar triangles, $S/s=l/(l-h)$.

Since $S=Vt$ and $s=vt$, the ratio of the displacements of the man and of the shadow is constant and equal to S/s. Hence the ratio of the velocities is $l/(l-h)$.



799. *Proposed by W. C. Eells, Whitman College, Walla Walla, Wash.*

The following problem was sent me by a farmer:

A and B each have 10-foot drills and are seeding a quarter section of land lying in a square. A takes the lead. How much farther does A travel than B? Some here contend that A travels no farther than B. Others claim A travels farther only on the first round and the last round.

To avoid misunderstanding a figure is added showing how A and B move; the width of the path is 10 feet.

The mathematician's interest in a practical problem (or in a problem which at least deals with the machinery of our daily life) is indicated by the fact that no solution of his problem has been received. Perhaps even the pupil is more interested in finding the number of nickels, dimes, and quarters in a fictitious situation than in finding the area of a triangle or the horse-power of an engine. The editor ventures the following solution:

Suppose A and B start as in the figure, with B not starting until A is at least half of the way around the field which is a square 5280 ft. on each side. Then A drives 5280 ft. N, 5270 ft. E, 5270 ft. S, 5250 ft. W. B during his first trip drives 5270 ft. N, 5250 ft. E, 5250 ft. S, 5240 W. These figures show (as we may also see by comparing the various rectangles) that in going North A goes 10 ft. more than B, in going East 20 ft., in going South 20 ft., and in going West 10 ft., or a total of 60 ft. more during each round.

On the very last round when the square is only 40 ft. on a side, A drives N. 40 ft., E. 30 ft., S. 30 ft., and W. 10 ft., while B who finishes the work drives N. 30 ft., then S. 20 ft. Hence A drives 60 ft. more than B on every round.

Since there are 5280/40 or 132 rounds, A drives 60x132 or 7920 ft. more than B.

We see also that if the width of the swath is W feet, then in each round A drives $6W$ feet farther than B. These results suggest another problem, Number 812.

800. *For high school pupils. Proposed by John J. Sheekey, St. Joseph's Normal Institute, Ammendale, Missouri.*

Find the volume of the figure generated by an equilateral triangle with side a when revolved about one of its sides.

Solution by Frank Marshall, Dickinson High School, Jersey City, New Jersey.

When an equilateral triangle is rotated about one of its sides as an axis, there are formed two cones whose altitudes are each $\frac{1}{2}a$ and the radius of whose base is $\frac{1}{2}a\sqrt{3}$. The volume of one cone is:

$$1/3 \times \pi \times \tfrac{1}{2}a \times (\tfrac{1}{2}a\sqrt{3})^2 \quad \text{or} \quad \pi a^3/8.$$

Hence the total volume is $\pi a^3/4$.

Similarly solved by *Junior Meserve, Redlands, Calif.*

PROBLEMS FOR SOLUTION.

811. *Proposed by M. Freed, Wilmington High School, Los Angeles, Calif.*

Find the general expression for the number that 3, 5, and 7 will each divide with the respective remainders a, b, and c, where $a<3$, $b<5$, and $c<7$. (See preceding Problem 797.)

812. *Proposed by the editor after solving Problem 799.*

Show that if the width of the swath is w, and the side of the square field is l (where l is a multiple of $4w$), then A travels $3l/2$ feet more than B.

813. *Proposed by Nelson L. Roray, Metuchen, New Jersey.*
Given the altitude on the side a, the bisector of $\angle A$, and the perimeter of the triangle, construct the triangle.
814. *Proposed by Michael Goldberg, Philadelphia, Pa.*
A variable chord CD bisects a given chord AB in the point E. Find the locus of the intersection of the lines AD and CB.
815. *For high school pupils. Proposed by the editor.*
The four bisectors of the angles of a parallelogram, ABCD, are drawn forming a quadrilateral, PQRS. Prove that PQRS is a rectangle.

VOCATIONAL ASSOCIATION MEETING.

The Vocational Education Association of the Middle West will hold the Tenth Annual Convention, at the Hotel Chase, St. Louis, Missouri, January 16, 17, 18, 19, 1924. A splendid program is being prepared, dealing with all phases of vocational education, including Agriculture, Home Economics, Vocational Guidance, Commercial Education, Trade and Industrial Education, Part Time Schools, Cooperative Industrial Training, Foremanship Training, and a host of other topics. The Committee on Local Arrangements is headed by Supt. J. J. Maddox, as General Chairman, assisted by others from the public and private schools of the city.

In addition to this program, a valuable commercial exhibit, displaying all the latest type of equipment for vocational education, will be a prominent feature.

Reduced railroad rates will be in effect, and any one interested in this phase of education cannot fail to profit from the meeting.

For further details and advance copy of the program, address the Secretary, Leonard W. Wahlstrom, 1711 Estes Avenue, Chicago.

OBSERVATIONS OF THE SOLAR ECLIPSE BY THE YERKES EXPEDITION PREVENTED BY CLOUDS.

After weeks of preparation at Camp Wrigley on Catalina Island for observing the sun's total eclipse on September 10, Director Edwin B. Frost and his party from the Yerkes Observatory were prevented by clouds from using the elaborate apparatus installed for observation. For several hundred miles along the coast the weather conditions were wholly unfavorable, Director Frost said, and all the American observers were deeply disappointed, except the combined party from Swarthmore and Allegheny observatories whose station was located in the state of Durango, Mexico.

Clouds at an altitude of 7,000 or more feet prevented the observers of the Yerkes, Carleton and Dearborn observatories from taking photographs of the eclipse. One or two of the smaller cameras were operated, but the larger instruments were not used.

Timed to the second, the moon passed before the sun and the sky turned a purplish green. The temperature at Camp Wrigley dropped ten degrees during the eclipse.

Dr. Oliver J. Lee, who was to have operated the Yerkes sixty-foot camera and who spent forty days in preparation on Catalina Island, worked under varying weather conditions, the temperature in the dark room of the coelostat at Camp Wrigley on September 6 being 118 degrees.

Director Frost reports that Camp Wrigley, some 1,300 feet above the sea, had about sixty-five astronomers and their associates at the time of the eclipse, and among these were representatives of not less than twenty-five institutions. A full account of the preparations made by the Yerkes Observatory for observing the eclipse, written by Director Frost, will appear in *Popular Astronomy.*—[*University of Chicago Press.*

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The White Motor Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of quotations as may interest you and be at his disposal.*

School examinations are particularly desired. Send your papers now.

Newspaper items contain many interesting problems—frequently much pseudo-science. Send them in.

Radio Questions Wanted. John C. Packard wants to know why we do not have some questions on Radio. "Barkis is willin'."

Acknowledgments: The receipt of examination papers is gratefully acknowledged from E. T. Smith, Salem, Ohio.

Questions for Solution.

427. *Proposed by L. P. Ramenstein, Clinton, Iowa—*

It is stated that a certain car had reduced the diameter of (rear) wheels on their car, claiming that they thereby increased the power."

Is this true? If so, in what sense is this true?

428. *Proposed by L. P. Ramenstein, Clinton, Iowa.*

Which pulls the easier (other conditions being equal) a big-wheeled or a small-wheeled wagon and why?

429. *Oxford Senior Local Examination, July 12, 1922, 9:15-10:45 a. m.*

How do these examinations conform to your ideas of good practice in General Science?

General Science I.

[Write General Science I at the head of each sheet of your answers, or you may receive no credit for your work. No Candidate may attempt more than FOUR questions in all. Answers should be illustrated by large, clear diagrams, wherever possible.]

1. Illustrate by means of a graph (which need not be drawn to scale) the way in which the volume of a quantity of water varies on being heated from 10°C. to 110°C. Explain briefly the chief points of interest in connection with your graph.

2. What is meant by the *melting-point* of a solid? Why is it important to determine melting-points accurately?

Describe how you would determine the melting-point of paraffin wax.

3. What is a *fuel*? Discuss the advantages and disadvantages attending the use of (a) coal, (b) coal-gas, as a fuel.

4. What conditions are necessary to bring about the precipitation of aqueous vapour from the atmosphere in the form of rain and snow?

Give a short description of some form of apparatus used for measuring rainfall.

5. How would you prepare a jar of ammonia, starting from ammonium chloride?

Explain why compounds of ammonia are useful as manures.

6. Describe with a sketch one way of proving by experiment that water is composed of oxygen and hydrogen in the proportion of eight parts by weight of oxygen to one of hydrogen.

7. Write an account of the various foodstuffs which are found stored in seeds.

Describe simple experiments which would enable you to decide whether the seeds of a certain plant contained (a) nitrogenous matter, (b) starch.

General Science. II.

[Write General Science II at the head of each sheet of your answers, or you may receive no credit for your work. No Candidate may attempt more than FOUR questions in all. Answers should be illustrated by large, clear diagrams, wherever possible.]

1. Construct a chart to show how the distribution of atmospheric pressure and the direction of the wind at any given time may be indicated over a large area.

State any inferences which can be drawn as to the probable state of the weather in the district represented by the central portion of your chart, giving reasons.

2. State the law which governs the expansion of gases under the action of heat.

How can it be shown experimentally that equal volumes of any two gases under the same pressure expand by the same amount for a given rise in temperature?

3. "The open fire is both imperfect as a means of ventilation and wasteful as a source of heat." Discuss this quotation at some length.

4. By what experiments would you show that the atmosphere consists mainly of two constituents, one of which is a supporter, and the other a non-supporter, of combustion?

5. In what ways do mixtures differ from single chemical compounds?

Explain *shortly*, with diagrams, three methods by means of which mixtures may be separated into their constituents.

6. How far does a plant obtain its food from the soil? Point out ways in which the roots of plants are specially adapted for obtaining such food.

7. For what reasons do we regard spiders and flies as belonging to different natural classes?

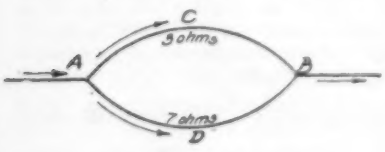
Write a short account of the life-history and habits of any one insect (e. g. the common house-fly).

Solutions and Answers.

420. *From a Cambridge or Oxford University examination paper, 1875.*

An electrical current may pass from A to B by either of two wires ACB, ADB, the resistances of which are 3 and 7 respectively. What will be the resistance of a single wire which replaced ACB and ADB in such a way as not to produce any alteration in the current in the rest of the circuit?

Solution by J. C. Scarborough, Santa Anna, Texas.



Let r = resistance in ACB
r_1 = resistance in ADB
R = total resistance between points A and B.

The conductance of AB is equal to the sum of the conductances of ACB and ADB; but since conductance is the reciprocal of resistance, the conductances of AB, ACB and ADB would be $1/R$, $1/r$, and $1/r^1$, respectively. Therefore,

$1/R = 1/r + 1/r^1$ or $1/R = 1/3 + 1/7 = (7+3)/21 = 10/21$,

$10R = 21$.

$R = 2.1$ ohms. (Resistance of a single wire to supplant the two and not alter the current strength.)

421. *From a College Entrance Examination Board examination paper, 1923.*

A liter of air weights 1.29 grams and a liter of helium 0.18 gram. If a small rubberized silk balloon weighing 10 grams is filled with 40 liters of helium, what is its lifting power?

Solution by J. C. Scarborough, Santa Anna, Texas.

1 liter (1,000 c. c.) of air weighs 1.29 gms.

1 liter (1,000 c. c.) of helium weighs 0.18 gms.

Buoyant effect upon 1,000 c. c. of helium = 1.11 gms.

Buoyant effect upon 40 l. (40,000 c. c.) of helium = 44.40 gms.

Resultant upward pressure on balloon weighing 10 gms. and filled with helium = 44.400 gms.—10 gms. = 34.44 gms.

422. *From a College Entrance Examination Board examination paper, 1923.*

The Dividing Lines Are Down

Social and industrial demands have drawn the physical sciences so close together that no one today pretends to say where chemistry ends and physics begins. Today, then, we must teach these subjects from books with a broad scientific viewpoint by authors who are not "pigeon-hole" enthusiasts, whose science is fundamental.

MILLIKAN AND GALE: PRACTICAL PHYSICS

A book which embodies the finest features of the authors' First Course in Physics, for ten years the most widely used book in American secondary schools.

MCPHERSON AND HENDERSON: CHEMISTRY AND ITS USES

Here are presented for beginners the facts which are of first importance today. These facts are taught as the needs of today prescribe their teachings, to the complete satisfaction of the student's interest and the practical requirements of college preparation. The book does more than teach chemistry, it arouses an enthusiasm for the possibilities of the subject in its endless growth and service.

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GEORGE M. GRAY, Curator

Woods Hole, Mass.

PLANT'S NEED FOR AIR INCREASED BY HOT WAVE.

Great lack of oxygen limits the rate of growth of roots at any temperature, but especially at high temperatures, experiments carried on in the Department of Botanical Research of the Carnegie Institution indicate, Dr. W. A. Cannon, staff member of that organization told the Botanical Society of America. This discovery, he said, has an important bearing on various problems associated with the distribution of plants and also on activities of economic plants.

A steel bar of uniform cross-section is 20 feet long and weighs 100 pounds. How much work is required to lift it from a horizontal to a vertical position, one end being kept always on the ground?

Solution by R. T. McGregor, Elk Grove, Cal.

The number of foot pounds of work = weight of bar $\times$ height of center of gravity where the bar is vertical = $100 \times 10 = 1{,}000$.

Query: This is undoubtedly the answer expected by the Board but is it the complete answer?

424. *From a College Entrance Board examination paper, 1923.*

Assuming that a bomb explodes immediately upon striking the ground, calculate the time that elapses from the instant it is released 1,000 feet above the ground until the sound of the explosion returns to that level.

Solution by R. T. McGregor, Elk Grove, Cal.

The time required for the bomb to drop 1,000 ft. under the influence of gravity is $\sqrt{[(2 \times 1{,}000)/32.16]} = 7.88$ sec., the time taken by the sound to reach the point of release from the ground, is $1{,}000/1{,}090 = .91$ sec. Hence the time that will elapse between the release of the bomb and the sound of the explosion at the point of release is $7.88 + .91$ sec. $= 8.79$ sec.

Solution by J. C. Scarborough, Santa Anna, Texas.

Sound travels 1,130 ft. per sec. at 20°C. hence time to travel 1,000 ft. is .88 sec. and answer is 8.76 sec.

WHY IS "WHITENESS."

Whiteness is caused by the structure of materials which are actually transparent. Snow, white porcelain, bird feathers, flower petals, fish bellies, milk, paper, and white paint, all get their "whiteness" in this way, physicists have found. When transparent substances are divided in many fine particles, the white light which strikes them is scattered by their multitude of surfaces. Ice, for instance, is colorless, but copped ice looks white. Ordinary white paint is a suspension in linseed oil of fine particles of solids known to be colorless and transparent in mass.—[*Science Service.*

UNIQUE BOTANICAL COURSES IN UTAH BY A UNIVERSITY OF CHICAGO SCIENTIST.

During the recent Summer Quarter of the University of Chicago, Professor Henry C. Cowles, of the Department of Botany, conducted a unique series of courses in Utah. The first weeks of the summer were spent with a University of Chicago class in botany in southern Utah and northern Arizona. After some days in the neighborhood of Provo and Great Salt Lake, a two weeks' automobile tour was made through Zion Canyon, the southern Utah desert, the Kaibab Forest, the Grand Canyon, Bryce Canyon, and the Cedar Breaks. A remarkable flora was discovered in these places, and especially at Cedar Breaks.

Following these weeks there was conducted a five weeks' summer session in field botany at Aspen Grove on the slopes of Mt. Timpanogos in the Wasatch Mountains. This class was composed of twenty advanced students from the University of Chicago and about the same number from Brigham Young University of Provo, Utah. The mountain camp, situated at an altitude of 7,500 feet, made easily accessible all types of vegetation, from the deserts of the Utah basin to the perpetual snow and glaciers of the mountain tops. The work was so successful that Professor Cowles has been asked to conduct a similar course in the summer of 1924.

Dr. Cowles who recently received the honorary degree of Doctor of Science from Oberlin College, is the author of *Vegetation of the Sand Dunes of Lake Michigan*, of *Plant Ecology*, and, with others, of *Starved Rock State Park and Its Environs*, and has been president of the Association of American Geographers, the Ecological Society of America, and the Botanical Society of America.

Advance Notes on Forthcoming Meeting
of

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

at

Indianapolis, Ind.

NOVEMBER 30 and DECEMBER 1

For the first time in the history of the Central Association the annual meeting will be held in the Hoosier Capital, Shortridge High School of Indianapolis being the headquarters and, together with the Arsenal Technical Schools and the Emmerich Manual Training High School, the host.

If the season is normal fairly mild weather may be expected at that time and several trips in the out-of-doors have been planned for some of the sections. The Physics section will probably motor to Bloomington to hear and see an illustrated lecture by Prof. Arthur Foley of the Indiana University on Saturday afternoon, Dec. 1st. The Geography section and other members who may wish to accompany them will travel over the same road, but more leisurely, under the direction of the Professors from the Geology Dept. of the State University, stopping to examine some of the many interesting features of the very varied country between Indianapolis and Bloomington. This part of Indiana has many wild and rough places, some of them in the glaciated part of the state and others in the limestone and sandstone districts. Gold and diamonds have been found in the concentrates in the stream beds of the terminal moraine country through which the party will go and the limestone country is full of sink holes and caves. There are immense quarries for limestone and huge plants for dressing it which can be visited. Arrangements will be made so that those who wish to go on these trips may be accommodated in autos or busses at very reasonable rates. Definite notice will appear in the program of the Association soon to be mailed out. Reservations as per the program should be made.

A good general program is assured, one of the speakers being Dean A. A. Potter of the Purdue School of Engineering.

Splendid section meetings are assured. Indianapolis is easily reached via many railroad and trolley lines. Reduced rates will be granted over Central Assn. Passenger lines if 250 or more members secure certificates and get them validated at Indianapolis. Come and mix with some if the most progressive teachers of science and mathematics in the country! *Remember!*
—November 30th and December 1st at Indianapolis!

FRANK B. WADE, President.

SHORTRIDGE HIGH SCHOOL, INDIANAPOLIS

KING SALMON RETURNS HOME AFTER LIFE SPENT IN SCHOOL.

King Salmon came back to spawn in the same tributary stream from which they started toward the sea. Evidence furnished by 25,000 of these fish introduced into Klamath River by the Fish and Game Commission of California indicate this fact, Prof. John O. Snyder, zoologist of Stanford University told the American Association for the Advancement of Science. They also range much farther at sea than was supposed, and keep together in one large school during their entire life in the ocean, he said.

Just before 250,000 one year old king salmon, reared at Fall Creek hatchery near Hornbrook, were turned loose in the Klamath river, 25,000 were marked by removing two of their fins. Two years later, 23 of the marked fish appeared in the river near the place where they have been released, and the following year 23 more of them were taken in localities ranging from Monterey Bay to the same place in Klamath River reached by those of the previous year.

The scales of these fish, Prof. Snyder said, were of such a peculiar structure as to make possible the identification of these among other fish, regardless of the mutilated fins.—[*Science Service.*

TELLS OF FIGHT TO SAVE AMERICAN CHESTNUT CROP.

Efforts to save the chestnut industry of this country, which is rapidly being swept out of existence by the chestnut blight, were described to the Northern Nut Growers Association in fourteenth annual convention at Washington recently by C. A. Reed, of the U. S. Department of Agriculture. He told of failures, disappointments, and promising successes in securing trees resistant to this damaging plant disease.

The chestnut blight is the result of a fungus growth which gets under the bark of chestnut trees and destroys the trees by girdling them. It was discovered in 1904 in trees on Long Island which had been brought in from Asia. Since that time, it has spread throughout the chestnut growing regions of the eastern United States, made gaunt white skeletons of what were once valuable food and timber trees, and threatens to completely wipe out the American sweet chestnut.

Among the once promising experiments which have proved a disappointment, according to Mr. Reed, is the cross of the native small sweet chinapin with the large Japanese chestnut which is almost without flavor. Seedlings from this cross developed nuts in eighteen months and during their early days appeared to be resistant to the blight. Later the blight also attacked them.

The most promising variety now appears to be the Chinese chestnut, Mr. Reed declared. The chestnut blight originated in China and the trees which have survived there are those not subject to it. Although the American sweet chestnut is the best chestnut known, the Chinese chestnut is also of good size and quality, and experiments indicate that it may become of commercial importance in this country and may replace the less resistant kinds. The Chinese trees, however, are small and not so well suited for poles or other lumber purposes as are the native trees now being killed by the blight.

There are regions in California, Oregon, Michigan and other parts of the country in which few chestnut trees are now raised but which are well adapted to them, and there is hope that the chestnut can be established on a commercial scale in such regions free from the blight.—[*Science Service.*

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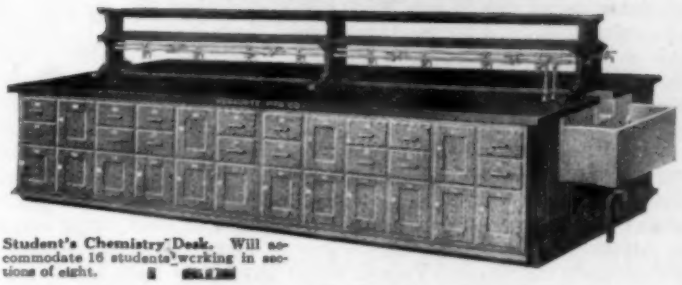

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HOW FAR AWAY IS THE POLE-STAR?

By Isabel M. Lewis

U. S. Naval Observatory.

Polaris, the Pole-star, is the most widely-known star of the northern hemisphere. Many who know nothing else about astronomy are able to point out the north star with the aid of the Pointers of the Big Dipper. Polaris is also the one star in the heavens with which school children are supposed to have a speaking acquaintance. Sirius may be the most brilliant of the stars, Antares, so far as is known, the most bulky, and Alpha Centauri the nearest, but it is Polaris that best serves our needs, and so most to be desired as an acquaintance.

A generation or so ago it was generally stated that the distance of Polaris was about 40 light years. This would place it among the nearer stars such as Vega, Aldebaran and Capella. The best available determinations of the parallax of Polaris, upon which the distance depends, now indicate that the Pole-star is approximately 200 light years away which corresponds to a distance of about 1,200 trillion miles. Just what do these figures mean to us? The light from a star 200 light years away takes 200 years to travel to the earth though it moves with the velocity of 186,000 miles per second. If it were possible for us to send an airplane to Polaris at the never ceasing velocity of 200 miles an hour about seven hundred million years would pass by before it would cover the distance. By that time both the sun and Polaris would have moved too far distant regions of the universe and would possibly have become non-luminous bodies.

Though the distance of Polaris is now authoritatively given as 200 light years with an uncertainty of not over ten or fifteen per cent. at the most we may still think of Polaris as a comparatively near star in a universe in which stellar distances run into the thousands of light years on the average. Any star within five hundred light years of the sun would be considered to be a member of our own local star cloud in the Milky Way, and, we might say, a rather close neighbor.

The parallax of a star, that distressing little angle so difficult for the astronomer to measure by the direct method and so difficult for the layman to comprehend is, we may say, the angular separation of earth and sun as viewed from the star in question. It is how big a base line of 93,000,000 miles, the distance from earth to sun, would look to an inhabitant of a little planet encircling one of these stars, if he had a telescope powerful enough to show the earth as well as the sun. Such a telescope would have to be inconceivably more powerful than any known to man.

The parallax of Alpha Centauri is 76 hundredths of a second of arc. It is the greatest known parallax. A star at a distance of one light year would have a parallax of one second of arc but no star is known to be this close to the solar system. The parallax of Capella, 55 light years away, is about .06 seconds and that of Polaris is about .016 seconds. These angles represent respectively how much each star would appear displaced in the heavens if viewed first from the earth and then from the sun 93,000,000 miles away. They represent also how far apart the earth and sun would appear to be in angular measure if it were possible to view them from the star in question. Is it little wonder that the astronomer meets with many difficulties in his attempts to measure these minute angles upon which the distances of the stars in miles or light years depend? Direct measurements of these small angles have been obviated to a great extent in recent years by the development of new methods for finding the distances of the stars.—[*Science Service.*

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A study made by the Life Extension Institute shows an annual economic loss of more than three billion dollars on account of preventable diseases and deaths. If the practice of having a periodic health examination becomes general, this loss will be greatly reduced, according to the council, which urges Federal, State and local health officials, the medical profession, voluntary health associations, women's organizations, industrial agencies, and the general public to cooperate in this campaign. The public is advised to go to reputable physicians or agencies for examinations. The National Health Council is a clearing house for 14 health organizations, including the United States Public Health Service which is a "conference member."—[*School Life.*

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This issue of the Locomotive Engineers' Journal is especially devoted to the workers' education, which is already transforming the outlook and destiny of millions of our fellow workers in Europe. It is education in the finest things of living for grown-up people who have maturity, judgment, and a vast field of experience—which is the raw material of knowledge. This is not something new and untempered; it is education in its highest and truest sense—for the word *education* means a drawing out, an expending and enlarging of the human personality, just as the word *college* originally meant a place where people read together and got their knowledge by mutual interchange of ideas, rather than an institution where knowledge is prepared in special doses and poured down the students' throats by the funnel process.

There are two reasons why every railway worker in the country, and especially engineers, are vitally concerned in this sort of education. Whether the next few years brings us to outright government ownership and operation of the railroads or some wiser form of joint control, such as the Plumb Plan provides, much greater responsibilities than any we have yet known must be assumed by the railwaymen of America. We must be prepared by an advancement in knowledge and education to meet the obligations of that day. Secondly, the spirit of the Brotherhood itself is the spirit of education—of elevating the whole race rather than making a few greedy giants. The ancients represented education by a flaming torch, because fire and learning alike possess the fraternal quality of growing greater as they are shared generously with others.—[*Locomotive Engineer Journal.*

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THE WORLD'S PRODUCTION OF TIN.

The world's production of tin in 1921 was only 109,704 metric tons, the lowest annual output since about 1908 and a decrease of about 16,000 tons from that in 1920, according to information now available in the Department of the Interior. Of this amount, the United States, the largest user of tin in the world, consuming in 1921 more than a third of all the tin produced in that year, obtained from its own deposits only four tons of tin, about three one-thousandths of one per cent of the world's output of primary tin in that year, or about one one-hundredth of one per cent of the new tin needed in this country. The United States is, therefore, absolutely dependent upon foregin sources of supply for a metal that is essential in times of peace and indispensable in times of war. The quantities of tin produced from all sources in 1920 and 1921 are shown in the following table, prepared by B. L. Johnson, of the Geological Survey, Interior Department.

In 1921 nearly all (98½ per cent) of the world's production came from the British Empire, the Dutch East Indies, Bolivia, Siam, and China. The outstanding feature of the world's production of tin is the large proportion of it that is produced within the British Empire—forty-four per cent in 1921. The Dutch East Indies produced twenty-five per cent, a notable increase in the face of adverse world conditions, and Bolivia only eighteen per cent, nearly 10,000 tons less than in 1920. Siam and China each produced between five and six per cent.

World's Production of Tin in 1920 *and* 1921.

(Estimated recoverable metallic tin contained in ore mined, in metric tons of 2,204,622 pounds.)

Country	1920	1921
Bolivia	29,210	19,750
British Empire:		
Australia	4,245	3,038
Cornwall	3,114	690
Federated Malay States	35,495	35,043
Nigeria	5,630	5,110
Nonfederated Malay States	2,050	1,830
Union of South Africa	1,480	790
India and other countries	3,570	2,000
China	11,487	6,231
Dutch East Indies:		
Banka	13,666	15,104
Billiton and Singkep	8,286	12,238
Siam	6,301	6,280
Other countries	1,230	1,600
	125,764	109,704

BOOK REVIEWS.

The Canadian School Geography by G. A. Cornish, College of Education University of Toronto. Pages XIV+450. 13x19 cm. Cloth. 1923. John M. Dent & Sons, Toronto, Canada.

Canadian Geography is written practically for the folk of Canada. It is written entirely from a Canadian point of view. Nearly one-third of the book has to deal with other countries in the world. There are in the text 236 maps and halftones, all being well selected for the subject they wish to illustrate. Perhaps no other book has come from the Canadian press

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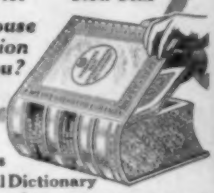

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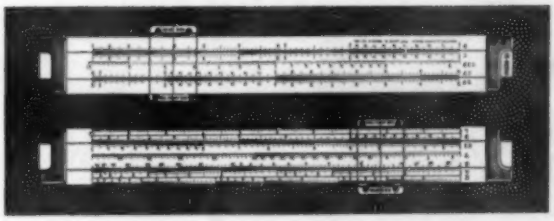

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C. H. S.

Masters of Science and Invention by Lloyd L. Darrow, Polytechnic preparatory Country day School, Brooklyn, N. Y. Pages V+350. 12½x19 cm. Cloth. 1923. Harcourt Brace & Co., N. Y.

This is a very splendid book and comes from the press at the proper time. It brings together in biographical form the leaders of invention of national reputation beginning with Galileo and closing with those of recent date. Of course, there are biographies of all these men in existance but there never has been a complete volume where the biographies of these men are given in one book. It is a very helpful and interesting book. In addition to the more important inventors and science men there are a number of pages devoted to those men of science who perhaps have not been classed as prominent in the scientific world as the twenty-five or thirty major sketches would warrant.

There are splendid halftones engravings of nearly all of the men and women mentioned in the major paragraphs. It is printed on a good quality of uncalendered paper in ten point type. It is a book that all science and mathematics teachers should have in their library.

C. H. S.

Psychology for Students of Education by Arthur Igaits, Teachers College, Columbia University. Pages XVI 489. 14½x20½ cm. Cloth. 1923. McMillan and Co., New York City.

This book has been written to meet the demand of all classes of people interested in the psychology of education. It brings out the facts as to how psychology has a bearing upon the principles of education and will serve as a text for college and normal school students as well as a general reference book. Principles of psychology are clearly discussed and apt illustrations are given. Rather more space is devoted to mechanics and dynamics than is usually found in texts of this kind.

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History and Social Science Curriculum by Ralph H. Bush, Joliet High School. 189 pages. 15x22 cm. Paper, 1923. Joliet Township High School Press.

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Social and Industrial Studies for the Elementary Grades by Jane B. Welling, Normal School Kalamazoo and Charlotte W. Calkins, Grand Rapids, Michigan. Pages XL 331. 13x19 cm. Cloth. 1923. $2.00.

Of the making of books there is apparently no end. Many there are that are not worth the paper they are printed upon. Not so with this, however. It is one of the most timely that has come to me in a long while. It deals primarily with the needs for food and clothing and shelter for children in the elementary grades. It is a very timely book and people interested in this line of work should possess themselves of a copy. Nearly all phases of the work are discussed. There is a long list of references appearing upon special matter treated. At the beginning of each chapter there is a page given to the topics treated in that chapter. It is a book well worth a place in the library of any teacher interested in the welfare of children.

C. H. S.

Problem Arithmetic, by Harry Brooks, John Cheverus School, Boston. Pages XV+331. 13x19 cm. 1923. Little, Brown, and Company, Boston.

This inductive drill book includes all the subjects of arithmetic which are considered of practical value to the pupil in after life. It covers the work of the elementary school from the fourth grade, and is arranged in lessons, each lesson beginning with explanations and illustrations that make the text itself the teacher. The author has evolved a new plan for teaching arithmetic according to the principles of the inductive method. Over 1300 concrete problems are given all based on the author's personal inquiries from heads and managers of commercial, industrial, and financial enterprises.

H. E. C.

Modern High School Algebra, by Webster Wells and Walter W. Hart' Assistant Professor of Mathematics, University of Wisconsin, Course for the Training of Teachers. Pages X+466. 12x18 cm. 1923. D. C. Heath & Co., Boston.

Though based upon the Wells and Hart *High School Algebra* the text has been rewritten and incorporates the changes suggested by the eleven added years of experience of its author and by the reports of the National Committee on Mathematical Requirements. Among some of the new features are: Increased emphasis on the formula, abundant use of geometrical material, the function concept, a consistent use of charts in the solution of problems, timed tests, the trigonometry of the right triangle, and lists of classified problems for drill purposes. Teachers who have used the author's *High School Algebra* will welcome this text and other teachers on examination will be led to adopt this excellent textbook.

H. E. C.

A First Book in Algebra, by Howard B. Baker, Lincoln High School, Jersey City, N. J. Pages IX+298. 13x19 cm. D. Appleton and Company, New York.

The reasons given by the author for this book are: First, What is most needed in an elementary algebra is an abundance of simple drill exercises, not a rearrangement of material. Second. To furnish a book with the diction within the immediate comprehension of the pupil. Correlation of algebra with arithmetic has been carefully preserved and "from the first the one practical use of algebra, the solution of formulas, is reated."

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Who's Who in America by Albert N. Marquis. 3520 pages. 14x19 cm. Cloth. 1923. $7.50 net. A. W. Marquis Co., Chicago, Ill.

This book is a bi-annual publication and has grown from apparently few pages to over 3500, and it contains at the present time approximately 2500 biographies. On the whole this is a splendid edition containing many names that have never appeared therein before, yet at the sametime there are many names which have been entirely omitted, perhaps not because of any fault of the editor but through the carelessness of the people who were asked to send a short account of themselves. This is selfish on the part of the contributors because frequently people would like to know something about their history and what they are doing. It is hoped that for the next publication, not only contributors to the work but those whose names do not appear, will feel the responsibility of helping to make the edition as nearly perfect as possible.

In a volume of this kind it is necessary to use many abbreviations. There are several pages given to the explanation of the abbreviations used. Also several pages are devoted to the pronounciation of the more difficult names. There is also given the state and country in which the contributors were born. There is an index of nearly 130 pages of the names found in the book. It is alphabetically arranged thus making it very easy for one to find a particular name.

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C. H. S.

Number Projects for Beginners, by Katherine L. McLaughlin, Associate Professor of Education, University of California, Southern Branch, Los Angeles and Elinor Troxell, Supervisor of the Primary Department, State Normal College, Dillon, Montana. Pages XIV+110. 13x19 cm. $1.60. 1923. J. B. Lippincott Company, Philadelphia.

This book presents a series of number projects for primary grades which were for the most part initiated by the children in connection with their interests and activities in and out of school. The projects are so arranged as to provide for an easy progression in the development of concepts in beginning number. Throughout the book the aim has been to arouse a consciousness and appreciation of the quantitative side of every-day life experiences, and care has been taken to include only those situations that appeal to the child in response to his conscious needs, such as making dominoes, domino games—number combinations, playing store, making reins, purses for toy money, making schoolroom curtains, and the like.

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Mathematical Theory of Finance, by T. M. Putnam, Ph. D., Professor of Mathematics, University of California. Pages IX+117. 14x21 cm. $1.75. 1923. John Wiley & Sons. Inc., New York.

Planned to cover a half-year college course for students of commerce this book is admirably fitted for colleges whose curricula will not permit the use of more extended texts. The fundamental principles of compound interest and annuities are thoroughly explained, with applications of the latter to bonds, sinking funds, amortization, and the principles of life insurance. The work requires only the equivalent of two years of high school algebra including logarithms. About 250 selected problems are given and there are several useful interest and annuity tables for purposes of computation.

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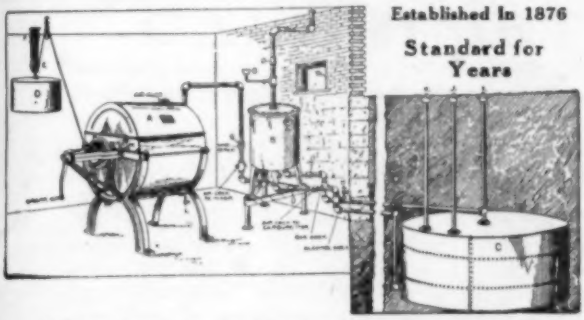

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Algebras and their Arithmetics, by Leonard E. Dickson, Professor of Mathematics, The University of Chicago. Pages IX+241. 13x19 cm. $2.25. 1923. The University of Chicago Press, Chicago.

The chief purpose of this book is the development for the first time of a general theory of the arithmetics of algebras, which furnishes a direct generalization of the classic theory of algebraic numbers. Every effort has been made to present the subject clearly and in strictly elementary form so that on the part of the reader only a knowledge of the simpler parts of a first course in the theory of equations is required This new theory of arithmetics of algebras is based on the theory of algebras over a general field, and develops at length a far-reaching generalization of the theory of algebraic numbers to the arithmetic of any rational algebra.

H. E. C.

The Psychology of Algebra, by Edward L. Thorndike, Margaret V. Cobb, Jacob S. Orleans, Percival M. Symonds, Elva Wald, and Ella Woodyard, of the Institute of Educational Research, Teachers College, Columbia University. Pages XI+483. 14x20 cm. 1923. The Macmillan Company, New York.

In the beginning it may be said that no teacher of algebra can afford to continue his work without reading and studying this book. It is full of thought provoking material, and is not the less valuable in that one may not be ready to accept off hand some of the conclusions reached by the authors. In part it gives the results of checking by experiments some of the principles laid down by authors of manuals of the pedagogy of algebra, by those who have applied psychology and psychological experimentation to the problem of the selection of subject matter in algebra, and by the reports of the National Committee on Mathematical Requirements.

Largely, however, the authors have devoted their attention to applying to the pedagogy of algebra the facts and principles which recent work in the psychology of learning has established. It emphasizes the dynamic aspect of the mind as a system of connection between situations and responses, and treats learning as the formation of such connections or elementary habits. It is impossible to give briefly a comprehensive outline of the contents, the book must be read. There are sixty-six tables, giving results of experiments, and data secured in various ways.

H. E. C.

Topics in the Calculus, by George Rutledge, Ph. D., Assistant Professor of Mathematics in the Massachusetts Institute of Technology. Pages VIII+250, 15x21 cm. Ginn and Company, Boston.

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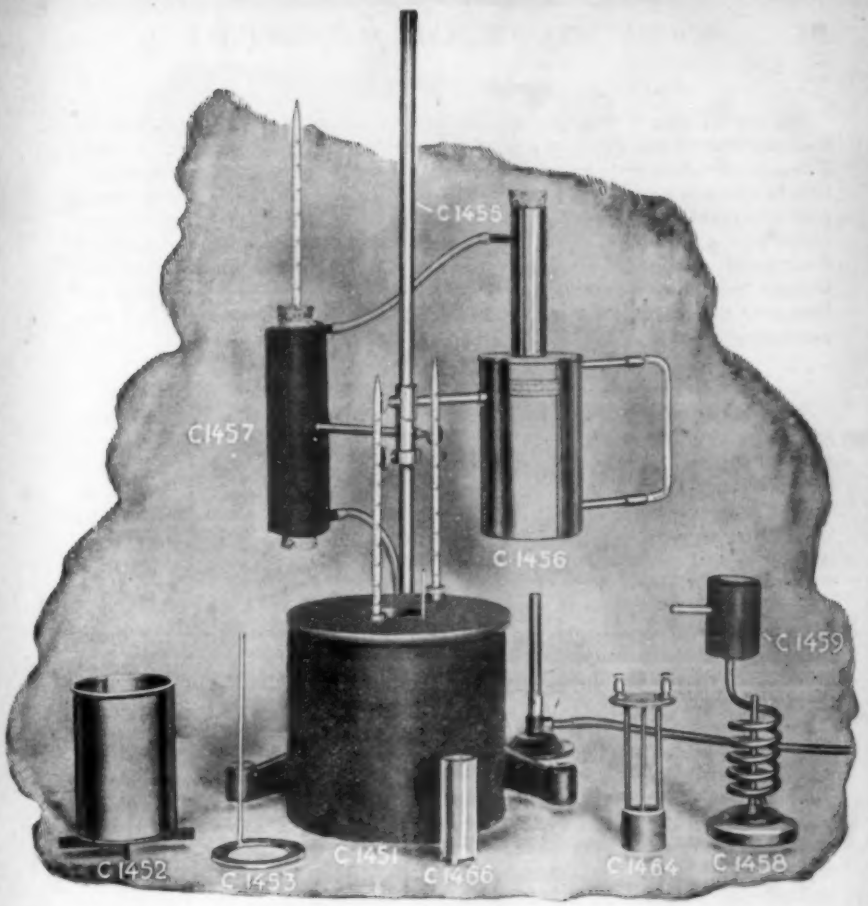

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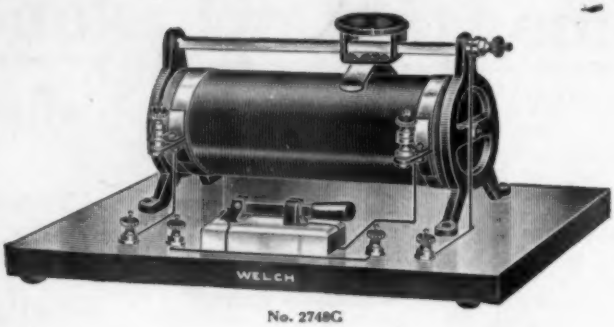

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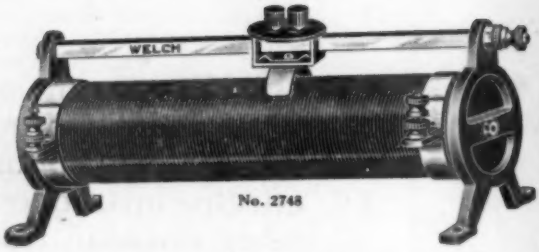

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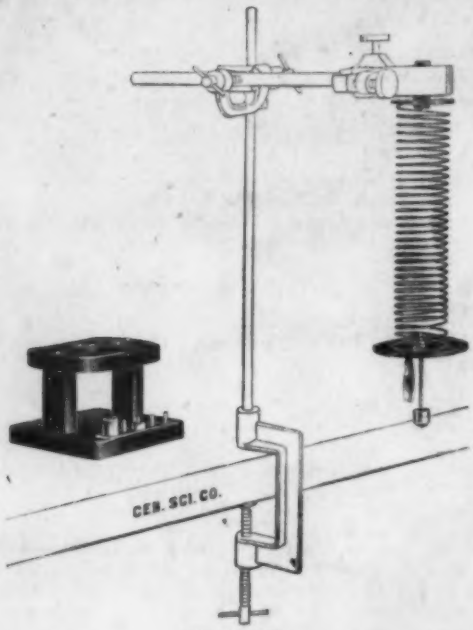

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